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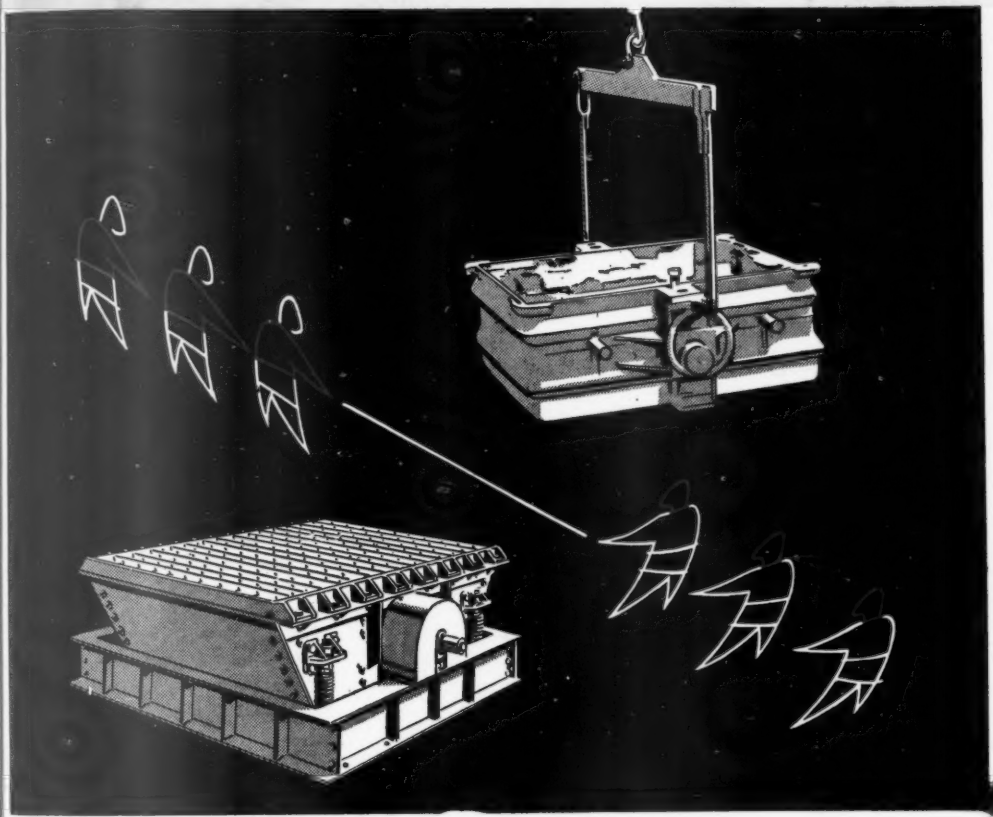

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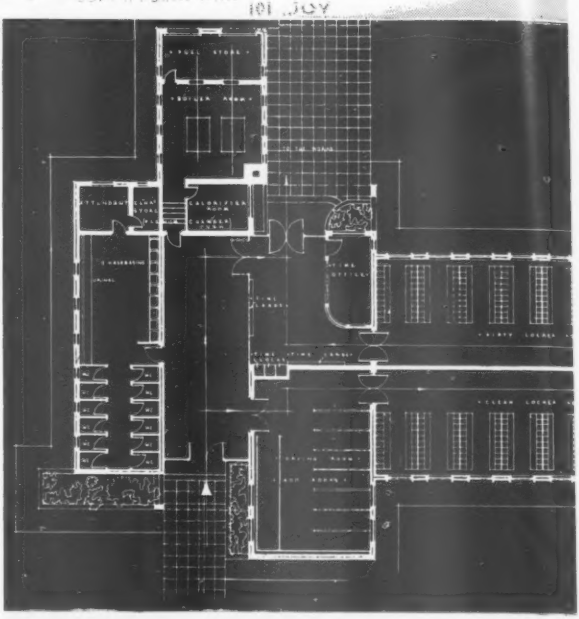

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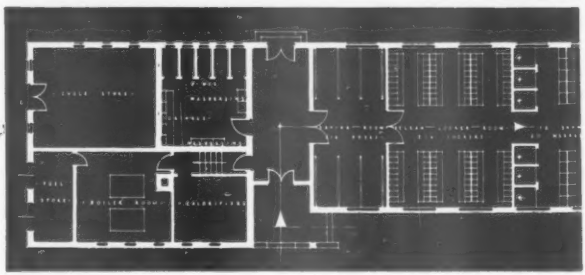

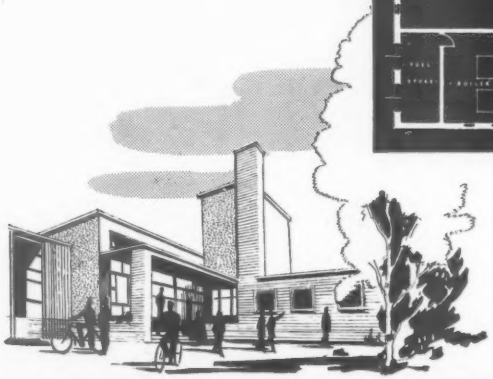

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Desulphurization

For the ordinary grey-iron founder, his standard approach to the problem of rendering sulphur innocuous is by the intelligent use of the sulphur-manganese equation balance. This postulates that the requisite manganese content is ascertained by multiplying the sulphur content by 1.7 and to this figure adding 0.30 per cent. The main factor to control is the sulphur content of the raw materials, which involves discarding doubtful scrap. The existence of "doubtful" scrap causes many foundrymen to use an excess of manganese as a safety measure. This may quite easily result in impaired machinability. The foundryman having access to supplies of raw materials—pig-iron, scrap, coke and limestone—of constant quality is indeed fortunate. When miscellaneous consignments of scrap are being received, a sharp watch must be kept to prevent any appreciable quantity of doubtful material—such as that emanating from works operating processes involving the handling of sulphur—from entering the cupola charge. The inadvertent melting of such material may easily result in the loss of a day's cast. This must not be taken to mean that all doubtful scrap should be ruthlessly discarded but that it should be used up—a little each day—so that it can have no serious deleterious effect on the metal melted. Thus, control on the cupola stage is just as important as the strict adherence to the sulphur-manganese balance.

For generations, the sulphur in the world's scrap pile was increasing and at the end of the 1914 war reached a dangerous level. Then the soda-ash process came into being and its extensive use by the blast-furnace owners and the larger foundries ameliorated the position. On the other hand, the world's stockpile has been subject to ever-increasing contamination with nickel. For the ordinary jobbing founder, this does not greatly matter, except where the wedge test is being used as a means of control and allowance should be made for the decreased chill effect. It is worthwhile for the jobbing founder to have a periodical check analysis taken, say, weekly. These results should not be just filed, but graphed and annotated with happenings during the week such as "normal," "high scrap-losses," "new consignments of pig or scrap used" and the like. After months of this system, the foundry owner has useful data for control.

This reduction in sulphur content has become imperative when manufacturing nodular-graphite cast-iron and here recourse is being had to magnesium alloys. We do not counsel the ordinary jobbing foundry to resort to this effective but — without due precautions — somewhat dangerous procedure. His line of action is to get the best out of charge control and the intelligent use of the sulphur-manganese balance.

More Foundry Amenities

Lake & Elliot, Limited, of Braintree, have been generous in their interpretation of the regulations as to the provision of bathing facilities for foundry employees and, naturally, the management is anxious that full use should be made of the facilities provided. Wisely, they have sent by post to each male employee a leaflet which illustrates and describes the amenities provided. Initially, the readers are told that "the decoration of the rooms and the equipment is the best obtainable and equal to those in a first-class hotel." The new department is air-conditioned, so that no matter what the weather conditions may be, both indoor and working clothes will be dry when required for use. The showerbaths are only to be available at leaving-off times, when a clean towel and soap will be provided free of charge to employees presenting their clock-card. After use, these are to be handed in, whereupon the clock-card will be returned. An innovation is the provision of electric razors and hair-cream dispensers. The leaflet points out that if the new arrangements clash with existing bus timetables, a representation should be made to the personnel officer. Finally, a footnote indicates that the new installation was open, on request, for public inspection on the day of the local Horticultural Show, August 18. Of the many methods open to foundries for the launching of enterprises of this type, the one chosen by Lake & Elliot, Limited, would seem to be of outstanding use because of the semi-permanent character of the appeal made.

Belfast College of Technology

Next year, this well-known educational organization will celebrate its jubilee. It was originally modelled on the lines of the Manchester College of Technology. Because of its late start, it avoided mistakes in technical education that had been made in England. For instance, the junior technical school has always been in advance. It attracted a better type of boy, had a more liberal curriculum and generally attained a higher level. Today, great emphasis is being placed on the development of technologies, especially at the higher levels. This is done through the media of part-time releases and periods of block releases from industrial establishments.

Amongst the many departments, there are those covering mechanical and electrical engineering, building, commerce, chemistry and textiles. The day-time attendance is of the order of 1,500, whilst including the evening schools, it controls the total number of students in all categories which number about 10,000 per session. In the engineering departments, most students work for the Higher School Certificate. Moreover, through its affiliation with Queen's, the College prepares students for the University degree in engineering. According to *Ulster Commentary*, from which the above has been abstracted, an extensive building programme is under way

OWING TO AN UNFORTUNATE TRANSPOSITION in last week's issue on page 159, the portrait of Dr. J. T. Berry was printed alongside the biographical notes applying to Mr. John Grice, co-Author of the paper "Development and Application of a Foundry Test for Assessing Shrinkage Behaviour in Grey Cast-iron"—and *vice versa*. Apologies are tendered to both the Authors and readers who may have been confused by this error.

Cooker Re-styled

After various improvements had been carried out to the interior design of their cooker to bring it to a peak of efficiency, AGA Heat, Limited, turned attention to the exterior and invited the industrial designer, Karl Otto, to suggest changes in its appearance. The result is a new de-luxe model, re-styled to conform with contemporary ideas of simplicity of design. There are no unnecessary knobs or panels to catch the dust or break the purity of line. Points of interest are as follow:—There are two ashpit doors, an outer and an inner; the thermostat is entirely hidden and is adjusted by a control placed immediately underneath the towel rail; ventilating grilles have been replaced by air inlets around the outer ashpit door; the new model is finished in cream vitreous enamel all over (except for the insulating lids which are chromium plated), and a raised portion of the top plate acts as a shelf.

"T.W.I." Developments

The recently announced reductions in the staff of the Ministry of Labour and National Service engaged on T.W.I. ("training within the industry" for supervisors) has been made possible because of the long-term policy of the Ministry to encourage not merely the larger firms but also the medium-size and small firms to take over T.W.I. themselves—something which has been done already by over 1,200 firms. There will be no reduction, however, in the type of training, known as "Institute" training—the training of firms' executives who are then able to undertake the training of supervisors within their own firms in the three T.W.I. programmes, "job instruction," "job relations" and "job methods" (to which a fourth programme "job safety" is about to be added). Information about the scheme can be obtained from regional offices of the Ministry of Labour and National Service.

Zinc Recovery from Tank Skimmings

What is claimed to be a new process of zinc recovery from the skimmings of galvanizing tanks is reported by the US Bureau of Mines. The originator is P. M. Sullivan, chemical engineer, and his process involves leaching the skimmings with spent electrolyte and hydrochloric acid, then placing the resulting solution in an amalgam cell where virtually all the contained zinc is recovered electrolytically. The following advantages are claimed: (1) Extremely high purity zinc is produced in a one-step operation from a relatively impure electrolyte; (2) no complicated electrolyte purification steps are required; (3) chlorine, a valuable byproduct, also is produced; and (4) current efficiency is very high.

Trade with Egypt

In view of inquiries about the effect of the current financial restrictions on United Kingdom trade with Egypt, the Board of Trade issued the following statement recently:—"Traders are advised that payment is not being made out of blocked Egyptian sterling accounts for goods exported to Egypt other than for goods delivered or shipped on or before July 27 and for goods in respect of which confirmed bankers' credits had been established on or before that date. There is no prohibition of exports to Egypt other than of arms and warlike material, though export licences continue to be required for certain kinds of goods."

Solubility of Hydrogen in Iron/Carbon/Silicon Alloys*

By V. B. John, M.Sc., and T. Evans, B.Sc., A.R.I.C., F. Inst. Fuel

The investigations described in this Paper form the second part of a programme of research on the equilibrium solubility of hydrogen in pure iron and ferrous alloys. The solubility of hydrogen, at a pressure of one atmosphere, in alloys of iron and carbon, iron and silicon, and iron, carbon and silicon, has been determined over the temperature range of 600 deg. C. to 1,000 deg. C. It was found that silicon caused a decrease in the solubility of hydrogen in both iron and in alloys of iron and carbon. Graphite was formed in the ternary alloys during the heat treatments given, and it appeared that the presence of graphite increased slightly the hydrogen solubility.

INTRODUCTION

Gaseous hydrogen has the unusual ability to penetrate many solid metals. This was found by Graham[1] in 1867, when he showed that various metals are capable of absorbing many times their own volume of hydrogen and carbon-monoxide, and evolving them again, on heating *in vacuo*. Since that time, many investigators have determined the quantities of gases present in ferrous metals. Until the work of Sieverts[2] in 1907, all the investigations had been concerned with the quantities of gases retained by metals after various heat-treatments. Sieverts was concerned with the equilibrium solubility of hydrogen in the metal under known conditions of temperature, pressure, and state of the metal. Since that time, two types of studies have been carried out on the absorption of hydrogen by ferrous metals, namely, practical investigations, concerned with the gas contents of metals during and after fabrication and heat-treatment operations, together with the effect of hydrogen on the mechanical properties of the metal and the more-academic investigations of equilibrium solubilities. Most published work on the subject of gases in metals deals with investigations of the first type.

The equilibrium solubility of hydrogen in pure iron has been studied by Sieverts and co-workers,[2 3 4] by Luckemeyer-Hasse and Schenck,[5] Martin,[6] and others. The absorption of hydrogen by iron has been shown to commence at around 400 deg. C., the hydrogen solubility increasing with rising temperature. There is a sharp rise in solubility on passing from the α phase to the γ phase, and a slight decrease in solubility on passing from the γ phase to the δ phase. Thereafter, the hydrogen solubility continues to increase with rising temperature, with a very large, sudden increase at the melting point.

Effect of Alloying Elements

Comparatively little work has been carried out on the effects of alloying elements on the equilibrium solubility of hydrogen in iron. Luckemeyer-Hasse and Schenck[5] found that the presence of nickel increases the solubility of hydrogen in iron, and that hyrogen solubilities in iron/chromium alloys are generally less than in pure iron. Martin[6] investigated the iron/silicon system, for silicon contents up to 5 per cent. He found that 0.5 per cent. silicon increases the amount of hydrogen absorbed, but that higher amounts of silicon cause a reduction in solubility. Davies and Evans,[7] investigating the iron/cementite system, found that with increasing carbon-content there is initially a decrease in hydrogen solubility, followed by an increase, the minimum occurring at about 0.5 per cent. carbon. Maximum hydrogen-solubility occurs at about 1.5 per cent. carbon. For carbon contents above 1.5 per cent., the hydrogen solubility decreases slightly to a value similar to that for pure iron (Fig. 1). They also found that the presence of 2.5 per cent. carbon as graphite, in an alloy of total carbon-content 3.4 per cent., increased the hydrogen solubility by more than 15 per cent. The present study consists mainly of determinations of the equilibrium hydrogen-solubility in reasonably-pure ternary alloys of iron, carbon, and silicon. The work was undertaken at the instance of the

* Presented at the annual conference of the Institute of British Foundrymen in Cardiff last June.

The Authors:

MR. V. B. JOHN has held a commission in the Technical-Armament branch of the Royal Air Force since October, 1954, and is now at the Aeroplane and Armament Experimental Establishment, Boscombe Down. He was educated at Bridgend Grammar School and University College, Cardiff, from which he graduated in metallurgical chemistry in 1951. From 1952 to 1954 he was a research student at University College, Cardiff, engaged in the investigation of the equilibrium solubilities of hydrogen in ferrous alloys and was awarded his M.Sc. for this work.

MR. T. EVANS was appointed lecturer in fuel technology at the University College of South Wales, Cardiff, in 1933, and is now senior lecturer. In 1915 he entered the University College of Wales, Aberystwyth, as Open College Scholar and Price Davies University Scholar, but service in World War I interrupted his studies. Resuming in 1919, in 1921 Mr. Evans completed the honours course in chemistry and joined the records section at DSIR headquarters, and was later transferred to the Fuel Research Station.

Joint Gases Sub-Committee of the Institute of British Foundrymen and the British Cast Iron Research Association, and is an extension of the work of Davies and Evans.[7]

Methods

There are several methods available for the determination of the gas content of a metal, but the majority of these require that the metal should be quenched before carrying out the determination. It is not desirable to use any method involving the quenching of the specimen because some hydrogen may be lost from the metal during the quenching operation. For any accurate determination of equilibrium-hydrogen solubility-values, the choice of method is therefore severely restricted. The methods which may be used involve either the measurement of the volume of hydrogen taken into solution as it is being absorbed by the metal, or the measurement of the gas evolved from the saturated metal without any intermediate quenching. Both methods involve holding the metal specimen for long periods at a constant temperature and under either a high vacuum or an atmosphere of hydrogen, with consequent difficulties in the selection of suitable reaction-tubes. Davies and Evans found that the measurement of hydrogen solubility by absorption was unsatisfactory for materials containing carbon, owing to the formation of methane affecting the external pressure. Consequently, they used the method of measuring the total gas evolution on vacuum heating; this method was also used throughout the present investigations.

Apparatus

The main requirements for an apparatus for the determination of hydrogen solubilities by vacuum extraction are a furnace, or furnaces, capable of operating efficiently over the required temperature-range, refractory reaction-tubes impermeable to both air and hydrogen at the working temperatures, a means of producing and maintaining high vacua, together with the necessary high-vacuum seals and valves, and a supply of pure hydrogen.

Furnace

The furnace used was wound with a coiled Kanthal wire, and worked over the temperature range 600 to 1,000 deg. C. This furnace was capable of taking two reaction tubes, each of 1-in. external diameter, placed side by side. Two thermocouples were used in conjunction with this furnace, (*a*) an unsheathed chromel/alumel thermocouple placed close to the winding at the mid-point of the furnace, this couple being connected to a potentiometric regulator, capable of maintaining the furnace-temperature constant to within ±3 deg. C., at 1,000 deg. C.; (*b*) a sheathed platinum/platinum-rhodium couple, placed at the geometrical centre of the furnace, connected to a temperature indicator and thread recorder.

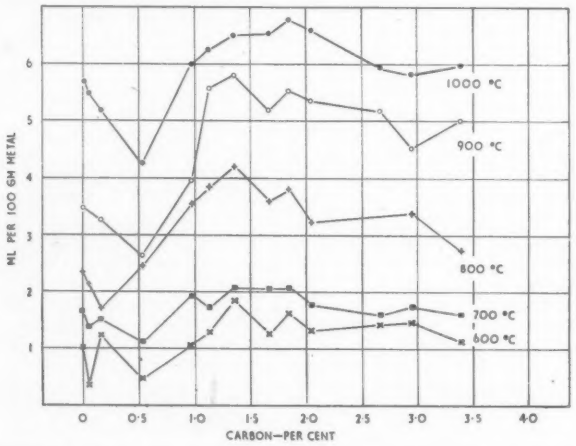


FIG. 1.—*Iron/carbon/hydrogen system (Davies and Evans).*

Refractory Tubes

A refractory tube to be used in hydrogen-solubility experiments must possess certain qualities. It must be impermeable to air and hydrogen at the working temperatures, must not absorb or adsorb hydrogen to any appreciable extent, and must be non-reactive with the metal specimen. Davies and Evans found that "Pythagoras" and mullite refractory-tubes were suitable for this type of experiment, and, owing to their availability, mullite tubes were used throughout the investigations detailed herein.

Vacuum-pumping System

The vacuum-pumping equipment consisted of a two-stage, rotary vacuum-pump, with an ultimate pressure of 10^{-3} mm. mercury, a two-stage mercury-diffusion pump, capable of working to an ultimate pressure of 10^{-6} mm. mercury, and a mercury Toepler pump, with a bulb of 1,000 ml. capacity. The diffusion pump could be backed by either the rotary pump, or the Toepler pump. When the Toepler pump was in use, the vacuum necessary for its operation was provided by the rotary pump. All sections of the pumping system could be isolated by means of stopcocks. The stopcocks used throughout the apparatus were of the high-vacuum type, made of Pyrex glass. Glass-to-glass, and glass-to-ceramic connections were made by means of cup and cone joints, sealed with vacuum wax. Glass-to-metal connections were also of the cup and cone type, and were either ground and sealed with mercury, or not ground and sealed with wax. Metal-to-metal joints were made with finely-lapped surfaces, with or without an "O" ring seal.

Hydrogen Supply.

The hydrogen used in the experiments was obtained from cylinders. This hydrogen contained some oxygen, usually less than one per cent. The

hydrogen was passed through a catalytic purifier, and the moisture so formed removed by passage over concentrated sulphuric acid, silica gel, and phosphorus pentoxide.

Gas Measurement and Analysis.

Gas extracted from the metal specimens during the experiments was collected over mercury, and measured in a constant-volume gas-pipette. After measurement, the extracted gas was transferred to a modified Haldane apparatus for analysis.

of the diffusion pump E, backed by the rotary vacuum pump N. After complete evacuation of the apparatus, tap T.3 was arranged to connect the rotary pump N with the backing vacuum-line (not shown), while the taps T.4 and T.6 were set to bypass the diffusion pump E and McLeod gauge. The apparatus could now be regarded as being in two sections, the evacuated section, including the Toepler pump B, and the vacuum reservoir F, and the hydrogen-filled section, comprising of reaction reaction tube G with manometer, the two sections

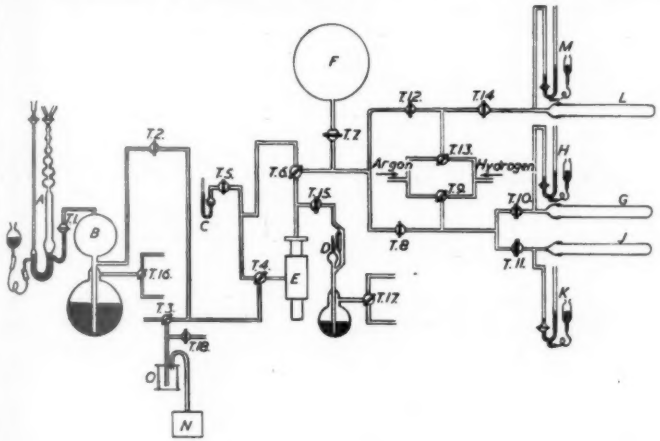


FIG. 2.—*Diagrammatic view of the complete apparatus used for determining the volume of the gaseous phase within a reaction tube. (A) gas-measuring bulbs; (B) Toepler pump; (C) coarse vacuum-gauge; (D) McLeod gauge; (E) diffusion pump; (F) vacuum reservoir; (G), (J), (L) mullite reaction-tubes; (H), (K), (M) mercury manometers; (N) rotary pump; and (O) moisture trap.*

METHOD OF DETERMINATION

Sources of Extracted Gas

During a vacuum-extraction experiment, the gas collected is derived from the following sources, the gaseous phase surrounding the metal (V_1), the gas evolved from the metal specimen (V_2), the gas evolved from the refractory and filling material (V_3), and gas which may have diffused through the tube walls from the surrounding atmosphere (V_4). When a "blank" experiment is carried out, the total-gas collected is derived from three sources only, and may be denoted by ($V_1' + V_3 + V_4$), where V_1' is the new volume of the gaseous phase. V_3 and V_4 have the same values as in an actual solubility determination. V_1 and V_1' can be determined, and ($V_3 + V_4$), the "blank" for the tube, obtained by difference. This enables V_2, the gas evolved from the metal specimen, itself to be calculated.

Volume of Gaseous Phase within a Reaction Tube

The complete apparatus, as used in the experiments, is shown in Fig. 2. The volume of the gas phase within a reaction tube was determined in the following manner. Hydrogen was admitted to a reaction tube, *e.g.*, tube G, to a pressure in the region of one atmosphere, and the tube and its contents allowed to reach equilibrium with the gas phase. The remainder of the apparatus was evacuated to a pressure of 10^{-5} mm. mercury by means being separated by stopcock T.10. The volume of the evacuated section was about 4,000 ml., while that of the hydrogen-filled section was about 70 ml.

After equilibrium had been reached inside the reaction tube, the pressure inside tube G was read on the manometer H. Stopcock T.10 was opened, and the pressure in the two sections allowed to equalize. T.10 was then closed and the pressure read on gauge C. The apparatus, as far as stopcock T.10 was evacuated through the Toepler pump, all the gas being collected, and its volume measured in the bulbs A. The volume of gas phase remaining in the tube G could be calculated, and the original volume of the gas contained in the reaction tube determined. When stopcock T.10 was opened to allow pressure equalization to take place, the metal/hydrogen system was immediately thrown out of equilibrium, and hydrogen tended to diffuse out from the metal specimen to restore the equilibrium. If tap T.10 was allowed to remain open for any length of time some of the hydrogen which had been in solution in the metal would be partitioned between the two sections of the apparatus. Consequently, tap T.10 was only open for a very short time, less than half a second, during which time the amount of hydrogen which had diffused out from the metal was zero, or of a negligibly-small value.

Extraction of Gas

It was shown by Davies and Evans[7] that equilibrium between the gas phase and the metal was

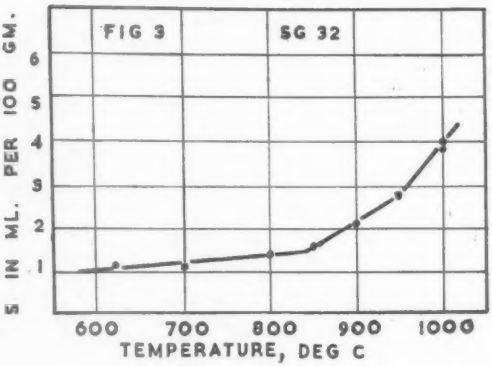
reached after four hours at 1,000 deg. C., and in under sixteen hours at 600 deg. C. In the present investigations, the length of the soaking period employed was sixteen hours, and the length of the extraction period was eight hours. The extraction period commenced with the withdrawal of portion of the gas phase surrounding the metal specimen, as described above. Upon the sudden decrease of pressure at the surface of the metal specimen, hydrogen began to diffuse out from solution in the metal. After collection and measurement of the gas phase withdrawn initially from the reaction tube, the vacuum reservoir, F, was isolated from the remainder of the system at cock T.7. Tap T.10 was then opened and the reaction tube, G, evacuated through the Toepler pump, and collected in the bulbs, A. When the pressure in the vacuum system had been reduced to 1 mm. mercury, the diffusion pump, E, was brought into the circuit and evacuation of the reaction tube continued down to a pressure of 10^{-5} mm. mercury (McLeod gauge). Samples of the gas phase, under which the metal specimen had been soaked, and also of the gas extracted from the metal, were taken, and analysed in the Haldane apparatus.

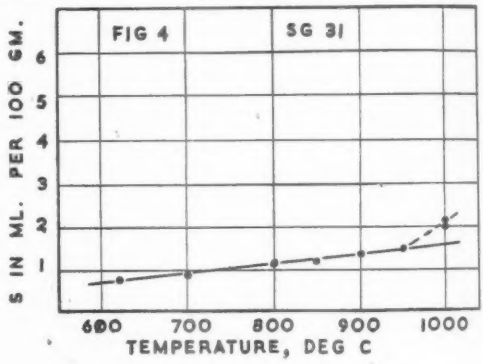
Accuracy

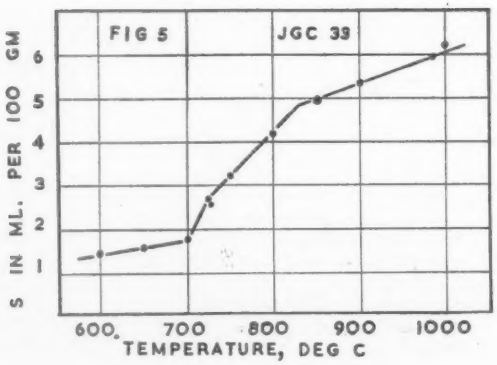
The hydrogen-solubility determinations were carried out at pressures of 760 ± 40 mm. mercury. All solubility values have been reported at a pressure of 760 mm. mercury and have been converted to that figure using the relationship $S \propto \sqrt{P}$, where P is the total pressure in the system, being the sum of the partial pressures of hydrogen and methane. Davies and Evans found this relationship to be a good approximation over a pressure range around one atmosphere. At a temperature of 1,000 deg. C., the soaking atmosphere contains very little methane, and any deviation from the relationship $S \propto \sqrt{P}$ will be small, while at lower temperatures, although the equilibrium methane-content of the gas phase is greater, a deviation from the $S \propto \sqrt{P}$ relationship will have only a minor effect because of the small values for the hydrogen solubility.

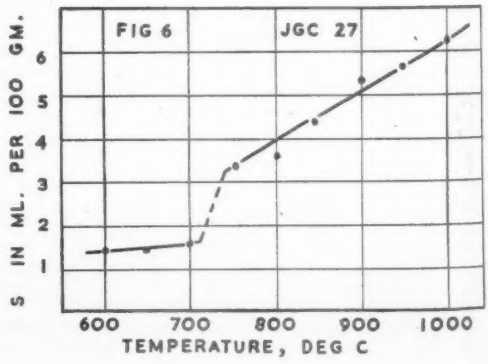
The accuracy with which the various quantities could be measured was as follows. Volume measurements could be made to within ±0.02 ml. and pressures could be measured to within ±0.5 mm. mercury. The accuracy of the methane analysis was ±0.5 per cent. methane. The most-critical phase of the determinations was the opening and

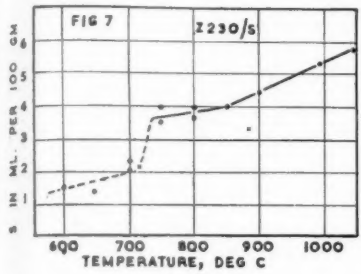
FIGS. 3 TO 6.—*Solubility/temperature relationships for various alloys investigated, viz.: Fig.* 3, *alloy containing* 2.86 *per cent. Si; Fig.* 4, *alloy containing* 4.36 *per cent. Si; Fig.* 5 (*chill cast*) *alloy containing* 1.42 *per cent. C; and Fig.* 6 (*chill cast*) *alloy containing* 1.70 *per cent. C.*

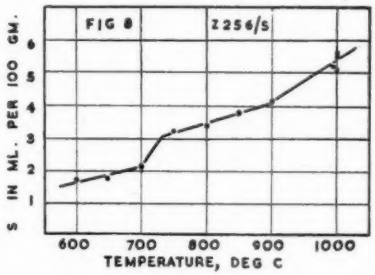


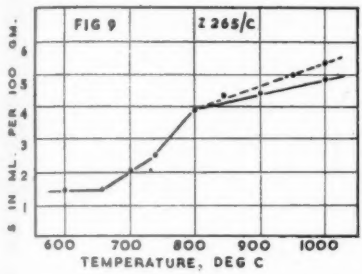


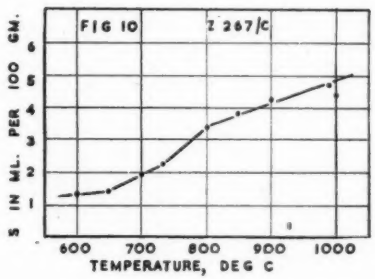












FIGS. 7 TO 10.—*Solubility / temperature curves obtained from the following alloys: Fig.* 7, *containing* 1.5 *per cent. C and* 0.5 *per cent. Si; Fig.* 8, *containing* 2.5 *per cent. C and* 0.6 *per cent. Si; Fig.* 9 (*chill cast*), *containing* 2.5 *per cent. C and* 1.8 *per cent. Si; and Fig.* 10, *containing* 3.3 *per cent C and* 0.4 *per cent. Si.*

closing of the stopcock connecting the reaction tube with the main vacuum-system at the commencement of the extraction period. The tap had to be open long enough to allow for complete pressure-equalization, and yet had to be closed before any appreciable diffusion of hydrogen out from the specimen had taken place. The accuracy of the whole determination was limited by this latter factor, and by the accuracy of the gas analysis. The accuracy claimed for the hydrogen-solubility experiments is ±0.2 ml. per 100 gm. metal.

ALLOYS USED IN DETERMINATIONS

The materials used in the hydrogen-solubility experiments were a decarburized ingot-iron, two iron/silicon alloys, and a series of reasonably-pure iron/carbon and iron/carbon/silicon alloys. The iron/carbon and iron/carbon/silicon alloys were specially prepared for this work, and were melted and cast *in vacuo* at the laboratories of the British Cast Iron Research Association. The ingot iron was decarburized, and its hydrogen solubility determined by Davies and Evans in their investigations. This specimen was used again in the present investigations as a means of providing a check on the apparatus and on the accuracy of the method.

The metal specimens were cylinders of length 3 in., and up to 0.75 in. in diameter, with an axial hole of 0.25 in. diameter. The specimens were dry machined to the required size, and degreased using alcohol and acetone. They were then dried, and weighed, and inserted into the reaction tube. The analytical composition of the specimens used is given in Table I.

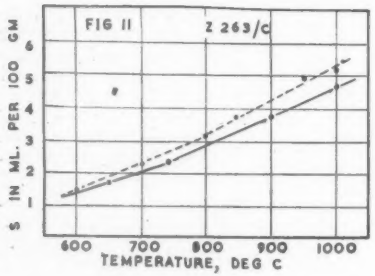
RESULTS

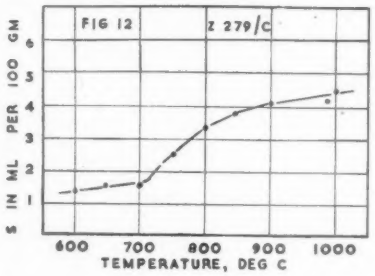
The hydrogen-solubility determinations were carried out at pressures in the region of one atmosphere, and the results have been corrected to a

TABLE I.—*Chemical Composition of Metal Specimens (per cent.).*

Alloy.	T.C.	Gr. carbon.		Si.	P.	Mn.	S.	Al.	N.
		Before.	After.						
G	—	—	—	0.002	0.013	0.048	0.044	—	—
JGC 27 ..	1.70	—	0.28	0.05	0.027	0.02	0.022	0.06	—
JGC 33 ..	1.42	—	0.49	0.06	0.029	0.02	0.016	0.11	—
SG 31 ..	0.023	—	—	4.36	—	—	—	—	0.006
SG 32	0.068	—	—	2.86	—	—	—	—	0.006
Z 230/S.. ..	1.52	—	0.40	0.49	0.028	0.05	0.034	—	—
Z 256/S ..	2.53	0.75	1.73	0.62	0.030	0.05	0.015	—	—
Z 263/C ..	3.34	—	3.28	1.80	0.026	0.06	0.014	—	—
Z 263/S.. ..	3.34	2.02	2.85	1.80	0.026	0.06	0.014	—	—
Z 265/C ..	2.47	—	2.30	1.70	0.030	0.07	0.030	—	—
Z 265/S.. ..	2.47	1.09	1.53	1.70	0.030	0.07	0.030	—	—
Z 267/C ..	3.31	—	2.46	0.38	0.028	0.06	0.026	—	—
Z 267/S.. ..	3.31	0.53	1.85	0.38	0.028	0.06	0.026	—	—
Z 279/C ..	3.41	1.76	2.18	2.08	0.028	0.02	0.017	—	—
Z 279/K ..	3.41	1.83	2.04	2.08	0.028	0.02	0.017	—	—

The letters shown with the "Z" series of alloys refer to the method of casting employed, viz., C—chill cast; S—sand cast; K—cast in keel moulds.





FIGS. 11 AND 12.—*Solubility / temperature relationships for the alloys:* 3.3 *per cent. C,* 1.8 *per cent. Si* (*Fig.* 11) *and* 3.4 *per cent. C and* 2.1 *per cent. Si* (*Fig.* 12).

pressure of 760 mm. mercury, using the relationship $S \propto \sqrt{P}$ and expressed in millilitres hydrogen (at N.T.P.) per 100 gm. metal, at an external pressure of 760 mm. mercury. The quantity measured was the volume of gas extracted from the metal specimens. The "hydrogen equivalent" was obtained by allowing for the methane content of the extracted gas (1 ml. methane ≡ 2 ml. hydrogen). Two determinations only were made with the decarburized ingot-iron. The results obtained agreed with those of Davies and Evans.

Iron/Silicon Alloys

The two alloys used contained 2.86 per cent. and 4.36 per cent. silicon, respectively. The solubility-temperature relationship for the alloy containing 2.86 per cent. silicon appeared to be in two sections, indicating a phase change in the alloy (Fig. 3). From the solubility results, the temperature at which this phase-change occurred would seem to be about 850 deg. C. There was microscopical evidence that a phase-change did exist in this alloy. The solubility values for the alloy containing 4.36 per cent. silicon (Fig. 4) were lower than those observed with the 2.86 per cent. alloy. The hydrogen solubility at 1,000 deg. C. was 2 ml. per 100 gm. metal, and this result was above the expected value, assuming the linear relationship to hold at temperatures up to 1,000 deg. C. (Fig. 4). There may have been a phase-change from α iron to γ iron occurring in this alloy at a temperature between 950 and 1,000 deg. C. The solubility of hydrogen in both these alloys in the ferritic range was slightly lower than the hydrogen solubilities in pure iron, and in iron/carbon alloys at the corresponding temperatures.

Iron/Carbon Alloys

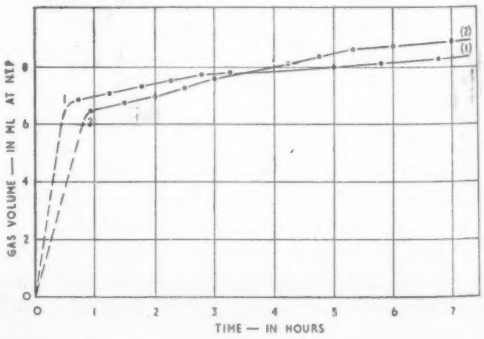
Hydrogen-solubility determinations were carried out on two iron/carbon alloys, containing 1.70 per cent. and 1.42 per cent. carbon. Both these alloys contained only one critical point, the A_1, at about 720 deg. C., within the temperature range 600 to 1,000 deg. C. Consequently, the hydrogen solubility-temperature curves should be in two sections with a change in gradient in the region of 720 deg. C. The solubility results for the 1.70 per cent. alloy showed these two sections, the portion of the curve between 600 and 700 deg. C. representing the solubility of hydrogen in ferrite, and the portion above 750 deg. C., that in the γ + carbide region (Fig. 5). With the 1.42 per cent. alloy two changes of slope appeared in the solubility-temperature curve (Fig. 6). There was a marked change in gradient at a temperature in the region of 700 deg. C., the A_1 critical point, and another change in slope at a temperature between 800 and 850 deg. C. No critical point was observed at this second temperature during a thermal-analysis experiment. The hydrogen solubilities in both these agreed with values obtained by Davies and Evans for alloys of similar composition.

Iron/Carbon/Silicon Alloys

Solubility determinations were made on ten metal specimens, representing six different alloy-compositions. The six compositions covered three total-carbon contents. One alloy, Z 230/S, contained 1.5 per cent. carbon and 0.5 per cent. silicon. Alloys Z 256/S, Z 265/C and Z 265/S possessed total-carbon contents of 2.5 per cent., and contained 0.6 per cent. and 1.7 per cent. silicon, respectively. The three remaining alloys, Z 267/C and Z 267/S, Z 263/C and Z 263/S, and Z 279/C and Z 279/K, had total-carbon contents of between 3.3 and 3.4 per cent., and contained 0.4 per cent. 1.8 per cent., and 2.1 per cent. silicon, respectively.

The results for the alloy containing 1.5 per cent. carbon, and 0.5 per cent. silicon yielded a solubility-temperature curve fundamentally similar to the curves obtained for the pure iron/carbon

FIG. 13.—*Graph of the rates of gas evolution at 1,000 deg. C. for specimen Z* 263/*C* (3.3 *per cent. C,* 1.8 *per cent. Si*) *when it contained no graphite* (*curve* 1) *and* 3.3 *per cent. graphite* (*curve* 2).



alloys (Fig. 7). A fairly-sharp rise in solubility was observed between 700 and 750 deg. C. This may be connected with the phase-change occurring at this temperature. The solubility of hydrogen in the alloy containing 2.5 per cent. carbon and 0.6 per cent. silicon was slightly less than the hydrogen solubility in a pure iron/carbon alloy with the same carbon content, as determined by Davies and Evans. The solubility-temperature curve for alloy Z 256/S did not show any pronounced change in gradient (Fig. 8).

Specimen Z 265/C, containing 2.5 per cent. carbon, and 1.8 per cent. silicon, contained no free graphite in its structure initially (Fig. 9), but it had graphitized almost completely by the end of the experiments. The solubility of hydrogen in this specimen at 1,000 deg. C. at the commencement of the series of experiments, when little if any, graphite was present, was 4.9 ml. per 100 gm. metal. This was less than the solubility in both Z 256/S, and a pure iron/carbon alloy of the same carbon content. The hydrogen solubility in alloy Z 265/C, at 1,000 deg. C., increased from 4.9 ml. per 100 gm. to 5.3 ml. per 100 gm. metal, during the experiments. This increase coincided with the formation of 2.3 per cent. graphitic carbon within the alloy. With the sand cast specimen, the graphite content increased from 1.1 per cent. to 1.55 per cent., and this was accompanied by a solubility increase from 4.95 ml. per 100 gm. to 5.2 ml. per 100 gm. metal. These observed solubility increases were just within the normal limits of experimental error, but similar increases were observed with most of the other specimens which graphitized during the experiments. In Fig. 9, for this alloy the continuous lines join points determined at the commencement of the experiments, while the broken lines join points determined toward the end of the series of experiments, *i.e.*, where the graphite content is greatest.

The results for specimens Z 267/C and Z 267/S, containing 3.3 per cent. carbon and 0.4 per cent. silicon, showed an increase in hydrogen solubility accompanying the formation of graphite. The chill-cast specimen contained no graphite initially, but at the end of the experiments there was 2.45 per cent. graphitic carbon present in the alloy. There was an accompanying increase in hydrogen solubility of from 4.4 ml. per 100 gm. to 4.8 ml. per 100 gm. metal, at 1,000 deg. C. (Fig. 10). The sand-cast specimen showed higher hydrogen solubilities. Again, there was an increase in graphite content during the determinations, and this was accompanied by an increase in hydrogen solubility.

During the hydrogen-solubility experiments the graphite content of alloy Z 263/C, containing 3.3 per cent. carbon and 1.8 per cent. silicon, increased from zero to 3.3 per cent. The hydrogen solubility at 1,000 deg. C. rose from 4.7 ml. per 100 gm. to 5.1 ml. per 100 gm. metal during the same period. In the graph for this alloy, continuous lines are used to join points determined during the first half of the series of determinations, while broken lines are used to join points denoting later results. (Fig. 11). The hydrogen solubility at 1,000 deg. C., in the sand-cast alloy rose by 0.65 ml. per 100 gm.

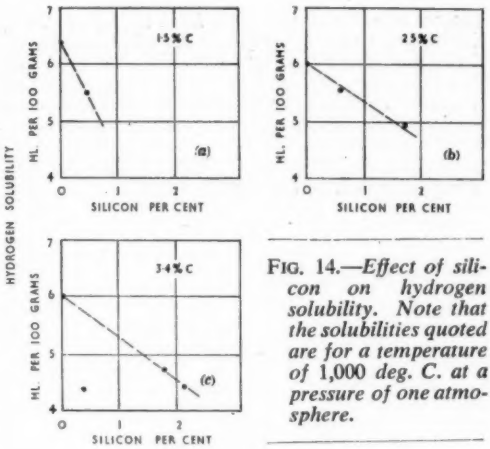


FIG. 14.—*Effect of silicon on hydrogen solubility. Note that the solubilities quoted are for a temperature of* 1,000 *deg. C. at a pressure of one atmosphere.*

accompanying an increase in graphite content of from 2.0 per cent. to 2.9 per cent.

Specimen Z 279/C and Z 279/K, of composition 3.4 per cent. carbon and 2.1 per cent. silicon, both contained graphitic carbon in their structures initially. The graphite content of both specimens increased only slightly during the heat treatment involved in carrying out the solubility experiments. Very little difference was observed in hydrogen solubilities determined at a temperature of 1,000 deg. C., at the commencement and at the end of the series of experiments, there being, if anything, a slight decrease in hydrogen solubility. The solubility of hydrogen, at 1,000 deg. C., was 4.5 ml. per 100 gm. metal (Fig. 12).

The amount of hydrogen absorbed, at 600 deg. C., by the iron/carbon/silicon alloys investigated, was 1.3 to 1.5 ml. per 100 gm. metal. This was the same as the absorption in pure iron/carbon alloys, at the same temperature. However, the hydrogen solubilities at 1,000 deg. C. were considerably reduced in the presence of silicon. Consequently, the average gradient of the solubility-temperature curves for temperatures between 600 and 1,000 deg C., was less for the iron/carbon/silicon alloys than it was for plain iron/carbon materials, and this rendered more difficult the location of a point of inflection on the solubility curve.

Nature of Hydrogen in Graphitized Alloys

During the investigations, it was noticed that the rate of evolution of gas from a metal specimen was not a constant factor, but tended to vary with the composition and structure of the material. It was found that the presence of graphite in the metal specimen was inclined to retard the rate of gas evolution. This effect was observed with a number of alloys. Fig. 13 shows the rates of gas evolution, at 1,000 deg. C., for specimen Z 263/C, when it contained no graphite, and when it contained 3.3 per cent. graphite.

It is believed that hydrogen is held in solution in pure iron, and in steels in the atomic form. The

slower rate of gas evolution from a grey iron may indicate that the hydrogen is contained within the iron in some other form, possibly as molecular hydrogen, or even as methane in interstices within the metal. Molecular hydrogen or methane would be incapable of diffusion through the metal lattice, and would have to dissociate before diffusion could take place, so increasing the time necessary for complete extraction of the dissolved gases.

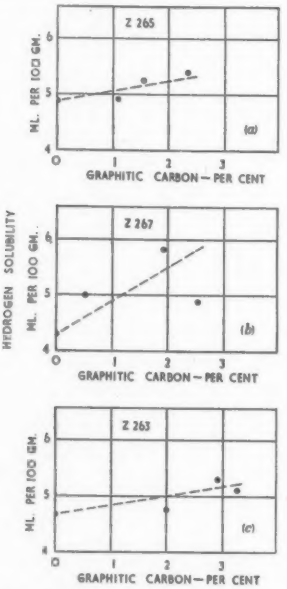


FIG. 15.—*Effect of graphite on hydrogen solubility for specimens Z 265, Z 267 and Z 263. (For details of the composition, see Table I).*

If hydrogen be present within the metal in the molecular state, or as methane, the probable location of such molecules would be at small voids, which may be present near graphite particles, such voids having been formed through differential expansion and contraction of graphite and iron. It is unlikely that molecules of hydrogen or methane exist within a steel or white iron, unless, perhaps, they are present at flaws or fissures within the metal. The methane detected in the gas extracted from all metal specimens containing carbon, is, in all probability, formed at the surface of the metal.

CONCLUSIONS

Values for the hydrogen solubility in certain alloys of iron/carbon, iron/silicon, and iron/carbon/silicon, have been obtained for temperatures between 600 and 1,000 deg. C., by measurement of the gases evolved from the metal on vacuum heating at 1,000 deg. C.

Determinations were made on two iron/silicon alloys, and it was found that the effect of silicon was to decrease the solubility of hydrogen in iron. This decrease may be explained as due largely to silicon increasing the range of stability of α iron. A slight decrease in the solubility in α iron at temperatures below 700 deg. C. was also noticed, but no definite conclusions can be drawn from this as the two iron/silicon alloys were not made from the highest purity materials, and slight variations in solubility values may be due to other elements present.

The results obtained for two pure iron/carbon alloys, containing 1.4 per cent. and 1.7 per cent. carbon, were in agreement with values quoted by earlier workers.[7] The solubility of hydrogen in these iron/carbon alloys, at 1,000 deg. C., showed a slight increase, about 0.7 ml. per 100 gm. metal, on the solubility in pure iron. Solubility determinations were carried out on a series of iron/carbon/silicon alloys. Hydrogen solubilities at 600 deg. C. did not change appreciably with composition, but the solubilities at 1,000 deg. C. showed a marked variation. Silicon seemed to cause a reduction in solubility (Fig. 14).

During the complex heat-treatment involved in carrying out the solubility determinations, all the ternary alloys graphitized. There was apparently a slight increase in hydrogen solubility with increasing graphite content, but the extent of this increase was found to be less than that observed by earlier workers[7] in a pure iron/carbon alloy. The effect of graphite was small, but there did seem to be a definite trend towards an increase in solubility in the presence of graphite (Fig. 15). Any increase in solubility in an alloy containing graphite may indicate that some hydrogen entered into solution in the graphite, or that some of the hydrogen was contained in voids, or fissures, which might be present near graphite particles. It was found that the rate of evolution of gas from an alloy containing graphite was slower than in the case of an alloy containing combined carbon only. In view of this, it is suggested that some of the hydrogen present in a grey iron is present in the form of either molecular hydrogen, or of methane, and that these molecules are likely to be contained in fissures or voids in the iron, rather than within the metal lattice.

Acknowledgments

The Authors wish to thank the Professor of Metallurgy at University College, Cardiff, for facilities to carry out this research, the British Cast Iron Research Association for the preparation of the pure iron/carbon and iron/carbon/silicon alloys, and the Joint Gases Sub-committee of the Institute of British Foundrymen and the British Cast Iron Research Association for their continued support and interest in the work.

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British Steel Castings Research Association

Third Annual Report, covering the period April 1, 1955, to March 31, 1956

The Annual Report of the British Steel Castings Research Association was issued recently and from it the following abstract has been prepared:

GENERAL

In presenting the third Annual Report for the year ending March 31, 1956, the Council of the Association records that during this period membership has increased by nearly a quarter; the new administrative re-arrangements referred to in the last Annual Report have been successfully completed; and, after initial setbacks, the building of the new laboratories has been started.

Council

Four meetings of the Council have been held under the chairmanship of Mr. C. H. Kain; the finance and the research-station committees have each met three times. Two meetings of the research committee have also been held.

Membership and Finance

The following ten companies have been elected as ordinary members of the Association during the year:—Babcock & Wilcox, Limited; David Brown Industries, Limited (foundries division); William Cook & Sons (Sheffield), Limited; Thos. Firth & John Brown, Limited; Forth & Clyde Steel Foundry (1932), Limited; A. Hamilton & Sons, Limited; Lloyd's (Burton), Limited; Renton & Fisher, Limited; Ryder Bros., Limited; and Vickers Ruwolt Proprietary, Limited, Australia.

The total membership of the Association at March 31, 1956, was 54.

Finance

In spite of the general rise in prices that has taken place during the year, the expenditure of the Association has been controlled well within the budgeted limit. This satisfactory result could not have been accomplished without the utmost vigilance by the finance committee and the permanent staff, and the Council is satisfied that the same thought and care is being devoted to the expenditure involved in the research-station scheme, which is estimated to amount to approximately £90,000.

Research Station

In the last Annual Report, members were informed that the Association had acquired a site at Petre Street, Sheffield, for its new laboratories, and in presenting the Report to the annual general meeting the chairman referred to the difficulties that arose in its development during April to May, 1955. These difficulties ultimately involved the abandonment of the site in July, 1955.

It is gratifying to record that within a period of only five months, a new and more pleasantly situated site was found in East Bank Road, Sheffield; a 200-year lease was negotiated and completed; all necessary approvals were obtained from the local and town planning authorities; new plans were completed, and the contractor was given possession of the site on November 22, 1955. Details of the revised scheme have been published. In spite of the inclement weather during the winter, good progress has been made with the building, and there is every prospect of the new premises being occupied during the autumn of 1956.

While these changes have unfortunately involved a delay of from six to eight months in the completion date, the Council is entirely satisfied that the new site has many advantages over the one at Petre Street, the abandonment of which was effected without serious financial loss.

Technical Advisory Committees

The reorganization of the technical advisory committee structure that was foreshadowed in the last Annual Report has been completed during the year. Five committees have now been appointed to advise the director in regard to the work of the Association in the fields of foundry practice, moulding materials, steelmaking, engineering and metallurgy. Each committee consists of approximately twelve members, and the membership will be reviewed annually to ensure that it matches the changing pattern of the research programme, and further to enable as many members as possible to participate in the committee work of the Association. It is intended that normally one-third of the membership of each committee will retire annually in rotation, but will be eligible for re-election which will be in the hands of the director and chairman of the committee acting in consultation. Meetings of all the new committees have been held during the year, and it is intended that under present circumstances, they shall continue to meet at approximately six-monthly intervals.

The Council takes the opportunity of acknowledging its indebtedness to these committees, and the former committees and panels which they have replaced. In particular, thanks are due to the chairmen of the committees: Mr. G. T. Harris, Mr. R. F. Horton, Mr. R. Lamb, Mr. A. B. Lloyd, Dr. J. R. Rait, who have been of the greatest assistance in carrying through the reorganization.

Conferences and Meetings

The second annual general meeting of the Association was held in London on July 5, 1955, under the chairmanship of Mr. C. H. Kain, and was attended by representatives of 24 members. Mr. A. H. Catton, Dr. C. J. Dadswell, Mr. A. B. Lloyd and Mr. W. Scott, the retiring members of Council, were re-elected for a period of three years, ending 1958.

One of the outstandingly successful events of the Association's year was the conference on "Steel Foundry Dust Control and Ventilation" held at York on October 13 and 14, 1955, and attended by about 120 delegates representing 85 per cent. of

the Association's membership. The conference, which was opened by Sir George Barnett, H.M. Chief Inspector of Factories, and Mr. J. H. Wigglesworth, secretary of the Iron, Steel and Metal Dressers' Trade Society, comprised five technical sessions to which eight papers were contributed by members of the Association's staff and other authorities in this field. Arrangements are being made to hold a similar type of conference, on the subject of steelfoundry moulding materials, in the autumn of 1956.

While no meetings of members have been arranged on a regional basis during the year, members of the Association's staff have been invited on five occasions to address meetings of regional organizations of the Scottish Steel Founders' Association and of the British Steel Founders' Association on the north-east coast and in the Midlands. The Research Association welcomes such opportunities for discussion with members.

Twenty-five meetings of members and committees have been held during the year. This is equivalent to one meeting per fortnight and has been found to provide adequately for the efficient working of the Association, and not to place an undue burden upon either the limited staff or the funds of the Association that are available for this purpose.

Liaison with Members

Special emphasis has been placed during the year upon visits to members, and there is no doubt that this policy has been entirely successful in furthering close contact and collaboration between the industry and its Research Association to their mutual advantage. In fulfilment of Council's intention that he should make a close study of the industry while acting as associate director, Dr. Sully has visited all the member foundries in the United Kingdom during the year, in addition to making a six weeks' visit to steel foundries and research organizations in the USA and Canada. As a consequence of these visits, the Association is now much better informed about the problems, conditions and personnel of the industry, and many members who formerly had little direct contact with the Association are now aware of its activities and the facilities which it offers to members. Increased liaison with members has resulted in a notable increase in requests for advisory services by the Association's staff, and during the year visits equivalent to approximately 250 man-days have been made by the staff to member foundries to advise on problems relating to steel making, casting defects, sand control or dust suppression. It is obvious that this service is much appreciated by members and it is intended to maintain it as an important part of the Association's functions.

Library and Information Services

The policy has been continued of building up as complete a collection as possible of current literature on steelfoundry subjects, while relying on borrowing and interchange to fulfil marginal needs and other requirements. This effort to avoid duplication of activities owes much for its success to the co-operation of the Science and Commerce Library of Sheffield City Libraries.

Although the greatest demand on the BSCRA library has been from the Association's own staff, some 600 loans to members have been made during the year.

Foundry journals and other literature from the USSR, Poland and Eastern Germany have tended to form an increasing sector of the published information field, and the year has seen a substantial increase in the demands for translations.

The Information Service has received more requests for information than in previous years and, apart from enquiries of a routine nature, 215 enquiries have been received which have involved either a literature search or a considered opinion by a member of the technical staff.

Publications

In addition to the Association's normal publications and research reports, two new films, with sound-track commentaries, have been produced by the staff to illustrate the Association's researches relating to dust control on pedestal and swing-frame grinding machines.

Extramural Research

The Association has continued to sponsor research at Cambridge, Reading and Sheffield Universities under the supervision of Dr. T. P. Hoar, Dr. P. F. Holt and Professor J. White respectively. In addition to undertaking specific research for the Association, the University of Sheffield also provides other general laboratory facilities for use by the Association's staff, and the Council gratefully acknowledges the help that is given in this way.

It has been decided to support the research that is being conducted by the British Electrical Research Association into the properties of cast steels at high temperatures by providing a grant for the year 1956-57, and the ERA has accepted the Council's nomination of the director to serve as a member of their committee that is advising on this research. Information made available to the ERA will be circulated to the BSCRA general metallurgy committee and to interested members.

External Relations

The Association's relations with many other organizations having interests in common have been strengthened during the year. Particular mention must be made of the Steel Founders' Society of America, the friendly help of whose technical and research director, Mr. C. W. Briggs, contributed so much to the success and value of the director's visit to North America in October to November, 1955. During this visit contacts were made or renewed with many important steel foundries and metallurgical research establishments, and a summary of information arising from this tour was circulated to members and the appropriate technical advisory committees.

Close collaboration has been maintained with the British Steel Founders' Association. During the

past year the director and Professor R. J. Sarjant as *ex officio* members attended meetings of the BSFA committee on industrial health and its sub-committee for practical work, whose advice has been sought on matters pertaining to the Association's work bearing on industrial health. The development of the Association's patents on the pedestal and swing-frame grinders has been handed over to B.S.F.A. Holdings, Limited, to whom the patents will be assigned, when granted, and who have consequently assumed the responsibility for making licensing arrangements with interested manufacturers. The Association's staff continues to give advice both to B.S.F.A. Holdings, Limited, to members and to interested manufacturers and has arranged and assisted in tests on these machines in collaboration with H.M. Inspectorate of Factories.

Liaison with BSFA has also been maintained on matters relating to specifications for steel castings and the director is an *ex officio* member of the BSFA Specifications Committee.

The Association is also represented on several committees of the British Standards Institution and on committees of the Institute of British Foundrymen dealing with topics of interest to the steel-foundry industry.

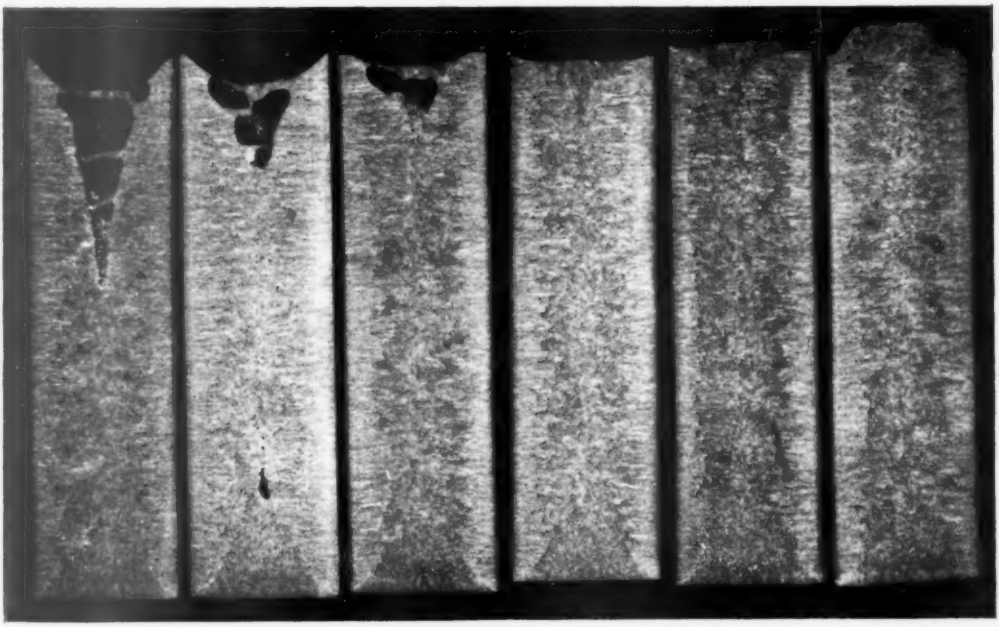
Co-operation with the British Cast Iron Research Association, particularly in regard to research on dust control, has continued, an understanding having been reached that research on problems associated with dust control on swing-frame grinding machines would be undertaken by BSCRA, and those related to foundry knock-outs by BCIRA.

Scientific and technical papers by members of the staff have been accepted for publication by a number of societies and institutions, including the Institute of British Foundrymen (International Foundry Congress) and the American Foundrymen's Society.

Staff

Professor R. J. Sarjant, O.B.E., continued as director of research until March 1, 1956, when he was succeeded by Dr. A. H. Sully in accordance with the arrangements described in the last Annual Report. The Council welcome the opportunity of recording their gratitude to Professor Sarjant for his invaluable services to the Association during an

FIG. 1.—*In the course of the investigation that is being made to determine the validity of the stearin-wax/steel analogy, the effect of gas evolution on the shrinkage produced in stearin castings has been studied by passing increasing amounts of carbon dioxide into a wax melt before casting a series of cylinders. The illustration (×3/5 approx.) shows a series of sectioned cylinders cast in stearin/3 per cent. naphthalene "alloy." It will be seen that, with gas-content increasing from left to right, the gradual disappearance of the shrinkage pipe followed by the gradual rise in the top surface of the ingot, is closely analogous to the conditions met with in the casting of steel. On subsequent treatment by a dye-penetrant technique it was revealed that the decrease in piping was accompanied by an increase in gas porosity.*



important stage in its development, and for his readiness to continue in an advisory capacity for a further year.

Some changes in internal organization have been effected during the year in preparation for the expansion in research staff that will be undertaken when the new laboratories are occupied. The following members of the staff have been promoted heads of sections: *Plant Engineering*—Mr. C. M. Stoch, DIP.ING., F.I.M.; Foundry Processes—Mr. J. M. Middleton, A.MET., A.I.M.; *Metallurgy*—Mr. W. J. Jackson, M.SC., A.R.I.C., A.I.M.; *Steelmaking*—Mr. T. A. Cosh, B.SC., A.R.T.C., F.I.M. Mr. G. M. Michie resigned during the year ment, and Mr. D. B. James, B.SC., Mr. P. Lambert, GRAD.I.MECH.E., Mr. F. Bownes and Mr. H. A. Powell have been appointed to the Association's staff.

As a consequence of this expansion envisaged it is anticipated that during the coming year the total number of employees of the Association will increase from 28 to approximately 50.

RESEARCH

In spite of limitations imposed by shortage of staff and inadequate facilities for experimental work, together with increased demands on the time of the staff in advisory services to members and in planning the details of the new Research Station, it is possible to report a substantial degree of progress in many of the investigations embodied in the programme for 1955-56. The Council is pleased to endorse and place on record the research committee's expressions of appreciation of

FIG. 2.—*Macrostructures* (×½) *and corresponding radiographs showing the comparison between the distribution of microporosity in air- and vacuum-melted ingots. It will be noted that in the vacuum-melted ingot (right) the shrinkage is almost entirely local, whereas in the air-melted ingot the shrinkage cavity merges into a large area of pronounced interdendritic unsoundness, surrounded by metal containing dispersed microporosity. The Association's investigations are aimed at making a quantitative determination of the relationship between microporosity and the mechanical properties of cast steels.*

the quantity and quality of the research staff's work during the year. In planning the research programme for 1956-57, the research committee in collaboration with the director has reduced the number of major investigations in order to ensure that the programme is commensurate with the staff and facilities which will be available during the coming year. Under present circumstances, the Association is obliged to exclude from its programme many topics, for example, non-destructive testing, that are of interest to members. It is confidently expected, however, that the expansion in facilities now in progress will permit a corresponding extension in the range of subjects that can realistically be included for investigation in the next few years.

The following account summarizes the progress which has been made in following the programme of research for 1955-56.

METALLURGY

Simulation Technique

The long range objective of this project is to evolve a practical technique for studying feeding problems in steel castings by using scaled-down castings either in steel or in any other material. Preliminary investigations have been carried out to determine the influence of the following factors on the form and distribution of macro-shrinkage in stearin-wax castings:—(1) Cooling rate; (2) superheat; (3) scale effect, and (4) wax composition.

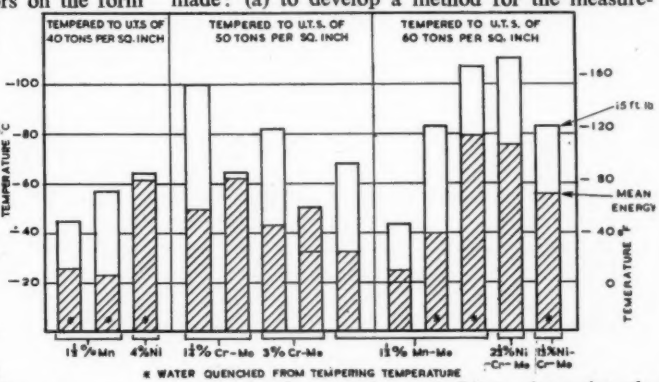


FIG. 3.—*Properties of commercially produced quenched and tempered alloy cast steels at low temperatures, compared on the basis of results obtained using the Charpy V-notch impact test. The temperatures indicated are those associated with the* 15 *ft.-lb. and the mean-energy levels.*

A series of wax cylinders was cast in which each of these factors was varied separately. Both pure stearin wax and a wax "alloy" containing 3 per cent. naphthalene were used. Neither superheat, scale effect, nor wax composition has much effect on the piping observed in stearin castings, but a dominating influence is exerted by the cooling rate. Decreasing the rate of cooling increases the depth of pipe in the casting; this is also true for steel.

The shrinkage produced in quickly cooled wax cylinders closely resembles that obtained for steel cast in metal moulds. Comparison with a sand-cast steel cylinder shows that in this case, although an air-cooled wax casting of the same dimensions displays approximately the same depth of pipe, the form and distribution of the shrinkage differ.

A similarity has been noticed between the shrinkage characteristics of sand-cast vacuum-melted steel, and stearin wax; thus it was thought that the analogy for sand-cast conventionally melted steel could be more fully realized if means were adopted for "gasification" of the stearin-wax melt. This possibility has been investigated by producing a series of wax cylinders which contained increasing amounts of carbon dioxide.

The effect of increasing gas-content of the wax is to decrease gradually the depth of pipe until it disappears, and then to cause a gradual rise in the surface of the casting. The decrease in piping is accompanied by an increase in blowhole formation. Although a closer simulation to the shrinkage produced in sand-cast steel is not realized, a striking resemblance to rimming steels and rising steels occurs. Fig. 1 illustrates this effect and shows a series of six stearin-wax/3 per cent. naphthalene alloys through which CO_2 was bubbled before solidification for times increasing progressively from left to right.

Microporosity in Steel Castings

Recent work carried out by the Association has suggested that interdendritic microporosity in steel castings may be of more widespread occurrence than is generally appreciated. In order to investigate the phenomenon, two approaches have been made: (a) to develop a method for the measurement of microporosity and (b) to determine the influence of microporosity on mechanical properties.

The detection of microporosity and the determination of its distribution in cast-steel sections has been found possible by radiography of thin sections prepared from the casting. This method, however, was considered unsuitable for adaptation to quantitative assessment of microporosity, and among the possible methods examined, density measurement appeared most promising. The decrease in density associated with the presence of microporosity is, however, very small and can be less than alterations in density accompanying variations in chemical composition. Thus, if density is to be used as an index of microporosity corrections must be made for variations in composition.

A preliminary investigation of the incidence of

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microporosity and its effect on mechanical properties was made by making two similar heats of steel, one of which was melted in air and the other under vacuum. Fig. 2 compares the etched structures and radiographs of thin sections of the two castings. In the vacuum-melted ingot the shrinkage is almost entirely local and the ingot exhibits only traces of microporosity. On the other hand, the casting melted in air shows dispersed shrinkage porosity, the shrinkage cavity proper merging into a large area of pronounced interdendritic unsoundness, surrounded by metal containing dispersed porosity, evident on the radiograph of the section. Tensile tests on test-pieces taken from these castings show the ductility of the vacuum-melted steel to be appreciably higher than that of the air-melted ingot.

Work is proposed to investigate the influence of ladle degasification as distinct from vacuum melting, since the former is the more likely method to be adopted in foundry practice.

Properties of Steel Castings at Low Temperatures

In view of the increasing preoccupation of users of steel castings with impact strength at low temperatures, an investigation has been undertaken to provide data on the low-temperature impact properties of commercially produced steel castings. The tests carried out have enabled the Charpy V-notch transition curves for each steel to be determined in various conditions of heat-treatment. A smaller number of Charpy keyhole-notch tests was made in order to determine the temperature associated with a 15 ft. lb. keyhole-notch value, which is the test figure required in most American specifications for steels for low-temperature service.

Measurements have been made on carbon steels and on low- and medium-alloy steels and the results have been published to members.

For plain carbon steels it has been demonstrated that, as for wrought steels, high low-temperature impact values are favoured by maintaining a high manganese : carbon ratio. It has also been shown that in the as-cast condition the impact properties are inferior to and more variable than the properties of annealed or normalized cast steels. In general the best low-temperature impact properties are obtained in steels which are both annealed and normalized.

For low- and medium-alloy steels the highest impact resistance at low temperatures is developed in fully hardened and tempered steels. The importance was also demonstrated of avoiding temper brittleness in steels known to be susceptible to it, by water quenching from the tempering temperature. These conclusions are exemplified by results on a 1½ per cent. manganese steel, which are summarized in Table I.

TABLE I.—*Charpy V-notch Results on a 1½ per cent. Manganese Steel assessed in Terms of the Percentage of Brittle (Cleavage) Fracture exhibited. The Advantage to be gained by Water Quenching this Steel from the Tempering Temperature is demonstrated.*

Heat-treatment.	Per cent. brittle fracture at	
	20 deg. C.	−20 deg. C.
Normalized and tempered (air cooled from tempering temperature)	60	90
Quenched and tempered (air cooled from tempering temperature)	0	80
Quenched and tempered (water cooled from tempering temperature)	0	30

The influence of tensile level, as controlled by the tempering temperature, on the low-temperature properties of hardened and tempered steels was also investigated. The general effect of decreasing the tempering temperature (increasing the tensile level) was found to be two-fold, namely:—(*a*) to lower the maximum impact value, and (*b*) to raise the transition temperature.

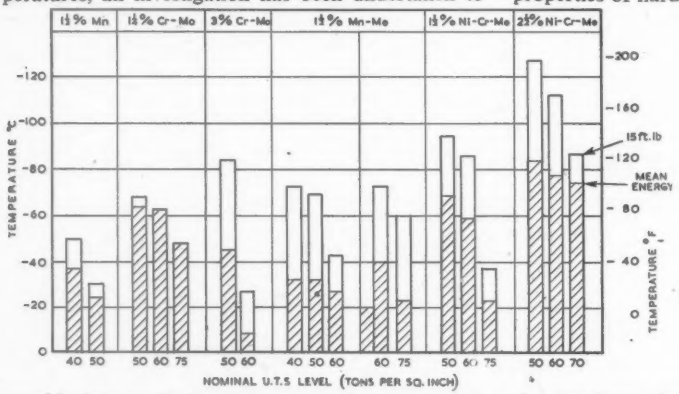

FIG. 4.—*Comparison of mean temperatures to give 15 ft.-lb. and mean energy using the Charpy V-notch impact test, for commercially produced steels hardened and subsequently tempered to different tensile levels.*

The results obtained on hardened and tempered steels are compared in Figs. 3 and 4. Fig. 3 summarizes and compares the results obtained on the various steels obtained from different suppliers on the basis of the temperature associated with the 15 ft. lb. Charpy V-notch impact value and with the mean-energy level (*i.e.*, the impact value which is the mean between the maximum value above the transition and the minimum value below it). Fig. 4 illustrates for each type of steel the effect of tempering to various tensile levels on the mean temperature for the 15 ft. lb. and mean-energy criteria.

No further work on this subject is proposed. The data which have been collected will prove to be very useful for the purpose of framing specifications for steels for service at low temperatures.

The Association wishes to thank Dr. L. Northcott, senior superintendent of applied research,

Armament Research and Development Establishment, Woolwich, through whose courtesy all the low-temperature impact testing on the low- and medium-alloy steels was carried out. Thanks are also due to Mr. H. F. Hall of the metallurgy division of ARDE, who supervized the testing.

Magnetic Properties of Cast Steel

Substantial progress has been made with an investigation to determine the influence of heat-treatment on the magnetic permeability of cast carbon steels of differing carbon content. Tests have been made on a series of steels of carbon content ranging from 0.10 to 0.35 per cent. in the as-cast, normalized and annealed conditions. For any given carbon content, the measure of improvement in magnetic permeability resulting from annealing, as compared with normalizing, has been demonstrated. The results of this investigation are illustrated by Fig. 5, which shows permeability plotted against flux density for a range of steels of differing carbon contents in the annealed, normalized and as-cast conditions. Mechanical properties of the steels were also determined.

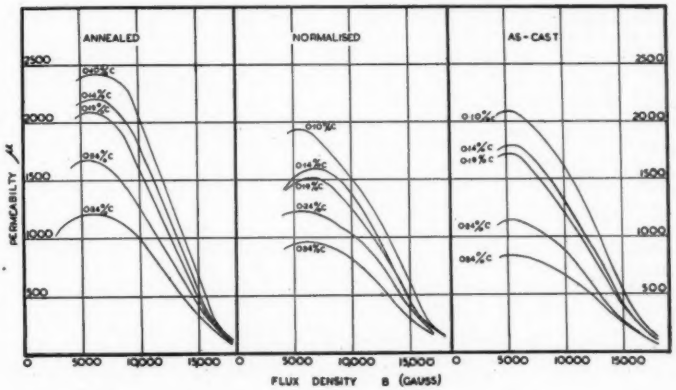

FIG. 5.—*Influence of heat-treatment on the magnetic permeability of a range of carbon steels* (0.10 *to* 0.35 *per cent. C.) has been studied in relation to the problem of developing optimum magnetic properties in minimum heat-treatment times. Some of the results are indicated in the accompanying curves showing magnetic permeability plotted against flux density for a range of carbon steels in the annealed normalized and as-cast condition. The improvement in permeability with annealing is shown.*

In order to take advantage of the superior magnetic properties of fully annealed material, while keeping furnace time and fuel consumption to a minimum, data have been obtained to determine the temperatures at which furnace charges may be withdrawn and air cooled, without impairment of the properties conferred by a full annealing treatment. Results indicate that decreasing the withdrawal temperature from one consistent with normalizing to one of full annealing, progressively improves magnetic permeability, with the exception that material withdrawn at 700 deg. C. and air cooled is slightly superior to the fully annealed material at higher magnetizing fields (above 100 Oersteds). The completion of this investigation by a determination of the effect of isothermal annealing and a further short study of the effect of small quantities of residual alloying elements on magnetic permeability, is in hand.

The Association's thanks are due to Edgar Allen & Company, Limited, and William Beardmore & Company, Limited, for assistance in the supply of material for this work, and to the former for the provision of testing facilities.

Boron-treated Steel Castings

It is well known that when boron additions are made to wrought steels, the hardenability of the steel is much improved and economies can, therefore, be effected in the use of expensive alloying elements. An investigation has, therefore, been made of the effect of boron additions on the properties of steel castings.

This investigation has been conducted in two phases:—

(*a*) to establish the reproducibility of the tensile, impact and magnetic properties of a cast boron-treated low-carbon 0.5 per cent. molybdenum steel. This steel is well known in its wrought form as "Fortiweld" and was developed by the United Steel Companies, Limited.

(*b*) to establish, for a series of medium-carbon, low-alloy steels of varying total alloy content, the extent in each case to which hardenability and mass effect are influenced by boron treatment.

By using four consecutive heats of "Fortiweld" composition, cast into clover-leaf moulds from a 100 lb. capacity basic-lined, high-frequency furnace, it has been shown that the tensile properties of this material in the normalized condition were consistently good. Ultimate tensile stress figures were of the order of 45 tons per sq. in., and were associated with an elongation of 23 per cent., a reduction of area of 49 per cent., and a 0.1 per cent. proof: stress ratio of 0.6.

Using the "Limited Rate of Cooling" test developed by the United Steel Companies, it has been shown that these improved tensile properties can be consistently developed in material in the normalized condition in round sections up to 3 in. dia.,

British Steel Castings Research Association

or flat sections up to a thickness of 1½ in. However, the impact properties were shown to be consistently poor, as demonstrated by the impact transition temperatures which are given in Table II. Room temperature Charpy V-notch figures were only of the order of 9 ft. lb.

Tensile and impact tests were also conducted in the double normalized condition and the results indicated that no advantage was to be gained by double normalizing.

TABLE II.—*Mean-energy and 50 per cent. Fibrous-fracture Transition Temperatures of Normalized Cast "Fortiweld" type Steel as Determined by the V-notch Charpy Impact Test.*

Heat No.	Mean-energy transition temperature (deg. C.)	50 per cent. Fibrous-fracture transition temperature (deg. C.)
1	+ 53	+ 65
2	+ 65	+ 50
3	+ 62	+ 62
4	+ 50	+ 58

Magnetic properties of cast "Fortiweld" steel in the normalized condition were shown to be reproducible, but at field strengths of less than 80 Oersteds the properties were inferior to the requirements of B.S. 1617:1950 Grade B material.

A number of boron-treated low-alloy hardened and tempered steels has also been investigated. Jominy end-quench hardenability tests have been carried out. The results indicate that in varying degrees boron has increased the hardenabilities of the four types of steel under investigation. Outstanding in this respect is the large increase in hardenability exhibited by adding boron to a 1½ per cent. manganese-molybdenum-type steel. Hardenability results are conveniently summarized by quoting distances as determined from the curves drawn by plotting hardness *versus* distance from quenched end of the Jominy test-piece, using a criterion of 80 per cent. martensite to represent complete hardening. These results are given in Table III.

The assistance afforded by the following in carrying out both sections of this project is gratefully acknowledged: William Beardmore & Company, Limited; United Steel Companies, Limited (Swinden Laboratory); William Jessop & Sons, Limited; and Edgar Allen & Company, Limited.

TABLE III.—*Comparison of Jominy Distances to give 80 per cent. Martensite on Boron-treated and Untreated Low-alloy Cast Steels.*

Steel type.	Jominy distance (sixteenths inch).
1½ per cent. Mn 1½ per cent. Mn + Boron	6 10
1½ per cent. Mn, Mo 1½ per cent. Mn, Mo + Boron	6½ 29
1½ per cent. Cr, Mo 1½ per cent. Cr, Mo + Boron	12½ 22½
1½ per cent. Ni, Cr, Mo 1½ per cent. Ni, Cr, Mo. + Boron	37½ >42

Rare-earth Additions to Steel Castings

A review of the literature on the subject of rare-earth additions to steel has been prepared and has been published to members. As a consequence of this survey a preliminary investigation has been planned in order to investigate the effect of small additions of rare-earth additions on the low-temperature impact properties of cast steels.

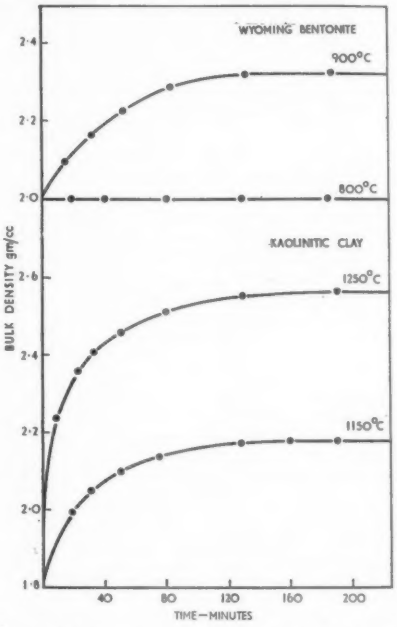

FIG. 6.—*Effect of heating on the bulk density of Wyoming bentonite and a kaolinitic clay. Pellets of both these materials were heated to various temperatures for times up to 200 min. and the change of density due to sintering was measured. It will be seen that in the case of Wyoming bentonite no sintering occurred on heating at 800 deg. C., whereas a change of bulk density from 2.0 to 2.3 g/c.c. occurred in about 100 min. at 900 deg. C. On the other hand, the kaolinitic clay required an appreciably higher temperature to produce sintering of the same order of magnitude, and it will be seen that a temperature of 1,150 deg. C. is required to produce a change in bulk density in the same period of time as the corresponding change in bulk density of Wyoming bentonite at 900 deg. C.*

FOUNDRY PRACTICE AND MOULDING MATERIALS

Sand Adherence to Steel Castings

The investigation by Mr. (now Dr.) D. F. McVittie, working under the supervision of Dr. T. P. Hoar at Cambridge University, for which the

Association has provided financial support, has been completed during the year.

The hypothesis reported in the last Annual Report, namely, that the burn-on of sand to steel castings without metal penetration is caused by the formation of liquid iron oxide penetrating into solid metal and the subsequent reaction of this oxide to form a mechanically strong and adherent sand-iron oxide magma, has been fully confirmed and investigated in some detail. The work is at present being written up as a report to the Association's moulding materials committee. It will subsequently be published.

A further investigation of certain types of sinterable mould washes, first discussed by Houseman, has been made. The general conclusion is that there is always a very delicate balance between a wash which sinters and provides an impermeable glassy surface to the mould, and one that in sintering merely tends to increase the effective pore radius of the compacted sand. The viscosity of the wash is also of crucial importance, as earlier indicated by Houseman. Incidentally to the work, improved methods of metallographic and petrographic examination of metal and refractory materials adhering together have been worked out, and these will be fully reported.

Properties of Mould Refractories at High Temperatures

Work on this investigation, which is financed by the Association, has been in progress at the Refractories Department of Sheffield University under the supervision of Professor J. White, the investigator being Mr. J. L. Evans.

The investigation has been concerned with a study of the effects of heat on the properties of clay-bonded sands, including the nature of the mechanism by which the peak on the conventional hot-strength curve is developed. The work has confirmed work carried out by the British Cast Iron Research Association, which has shown that no peak occurs with short times of heating. It has been shown that the peak develops as a result of a time-dependent sintering process following thermal decomposition of the clay. The sintering process is independent of the decomposition process, but is related to the ultimate refractoriness of the clay; *e.g.*, bentonites have a higher decomposition temperature than kaolinites, but sinter and develop peak strengths at lower temperatures than the latter. Both decomposition rates and sintering rates have been measured as functions of temperature, and the results of this study indicate that the times involved in development of the peak are such that they are likely to be of significance with respect to the behaviour of sand under actual casting conditions.

The latter point is illustrated by Fig. 6, which shows the change of bulk density on heating pellets of Wyoming bentonite and of a kaolinitic clay at various temperatures. It will be seen that, whereas the former shows an appreciable increase in bulk density (amount of sintering) on heating at 900 deg. C., a temperature of 1,150 deg. C. is required to produce a corresponding increase in a comparable time in the case of the kaolinite.

The effect on the strength of cooling from temperatures above and below the peak has also been investigated. The results show that softening above the peak is due to the presence of a liquid phase which solidifies on cooling so causing an initial rise in strength. On further cooling a fall in strength occurs due to dfferential contraction of the clay and aggregate. In the case of silica sands, this is followed by a second fall-off in strength to very low values at the temperature of the quartz inversion. In the case of olivine sands and firebrick aggregates of the "compo" type, which have a uniform contraction, this second fall-off in strength is absent and the residual strength at low temperatures is considerably higher.

The development of hot strength in zircon sand bonded with Wyoming bentonite has also been investigated and compared with that of bentonite-bonded silica sand of similar grain size. The peak temperatures were approximately the same in the two cases but the maximum hot strength developed by the zircon sand was approximately twice that of the silica sand. Evidence of considerable liquid formation in the zircon-sand test-pieces above the peak temperature was also observed. The residual strength of the zircon sand after cooling was much higher than that of silica sand.

Work on the rate of decomposition of clays has been extended to include studies of the effects of compaction and of wetting and subsequent drying to simulate the condition of the clay in a milled and rammed sand. The results show that while compaction decreases the decomposition rate at a given temperature to a significant extent, a much more marked retardation occurs in the case of swelling bentonites which have been agglomerated by wetting and drying. With non-swelling clays, *e.g.*, kaolinite and non-swelling bentonite, on the other hand, the latter treatment has little or no effect on the rate of decomposition. This should have a bearing on the relative life of swelling and non-swelling bentonites in practice.

Further work will be concerned with the effect of such temperature-dependent changes on the interaction of the sand with molten metal. This will bring into operation the new 30-lb. capacity high-frequency electric melting furnace that has been purchased by the Association during the year and which is installed at Sheffield University pending completion of the Research Station.

(To be continued)

Alar, Limited, 3, Albemarle Street, London, W.1, has just issued a new data sheet carrying the caption "Notes on the Heat-treatment of Aluminium-alloy Castings." The appellation "data sheet" is becoming something of a misnomer as this one runs to six sheets. In truth it is an excellent technical paper covering every important aspect of solution, and precipitation treatments. Included are two tables giving "Heat-treatment Times and Temperatures" and the "Mechanical Properties of Heat-treatment Alloys." This useful data sheet(s) is available to readers on writing to Albemarle Street.

Precision Investment Casting Conference

Representatives of about thirty precision investment casting foundries attended a conference held in Holland in the early summer. A number of lectures on technical subjects, a visit to the Philips Works and a sight-seeing trip gave the participants the opportunity to exchange ideas. The titles of the papers presented were as follow: "Review of the Properties of Stellite Alloys," by M. Riddihough (UK); "Tentative and Finalized Specifications in USA for Investment Castings," by V. di Sambuy (Italy); "Could Mistakes in the Past in the Precision Foundry be Avoided in the Future?" by B. G. Helders (Holland); "The Philips X-Ray Intensifier," by H. J. Meerkamp van Embden (Holland); "Defects in Precision Castings," by A. Bouman and C. Nieuwenhuis (Holland); "Approach towards the Classification of Casting Defects in Investment Casting," by W. H. Sulzer (Switzerland); "Decarburization in Investment Castings and in Heat-treatment," by N. J. Grant (USA), presented by W. A. Matejka (Switzerland); "Price Estimation and Cost Calculation in Precision Casting," by F. Polzgüter (Germany), and "Some Applications of Mathematical Statistics in the Microcast Process," by J. J. Tiedema (Holland). The participants agreed that these conferences serve a useful purpose, and it was decided unanimously to hold the next in England in 1957. The previous congress was held in September, 1955, in Zurich.

New Domestic-appliance Factory

Starting in a small way this summer, Sunbeam Electric, Limited, intend to build up steadily at East Kilbride until their new 200,000 sq. ft. factory is geared to full production and exporting domestic appliances all over Europe. The company have just started production with 150 employees, a number which it is expected will be increased steadily until some 2,000 are employed. The demand for products and the availability of supplies are two factors which will largely determine the rate of development at the new factory—which is to be one of the biggest of its kind on this side of the Atlantic. Initial production will be concentrated on two appliances, the Mixmaster and an electric-shaving machine known as the Shavemaster.

The firm is a subsidiary of the Sunbeam Corp. of Chicago, said to be the biggest enterprise of its kind in the US and having thriving factories also in Canada and Australia. The plant is being laid out on modern lines, with spacious, well-lit, and well-ventilated bays. The plans make provision for extensive recreational facilities alongside the works, and an option on adjoining land has been taken to permit the present accommodation to be trebled.

Latest Foundry Statistics

According to the *Bulletin* of the Iron and Steel Board, the number of people engaged in steel founding on June 9 was 20,160; this shows an increase of 40 as compared with a month earlier and 250 more than a year ago. The estimated average weekly production of steel castings during June was 6,300 tons, a figure roughly the same as the two preceding months.

Figures from the British Bureau of Non-Ferrous Metal Statistics state that the output of copper-base alloys during June was 6,766 tons. During the first half year of 1955, the production was 35,391 tons, whilst this year it was 39,446 tons.

Tribute to Bessemer

A special programme of steel films is being screened in Sheffield's Central Library on September 5 as a tribute to Sir Henry Bessemer, inventor of the Bessemer steelmaking process. It was at the British Association meeting in Cheltenham 100 years ago that Bessemer gave the first details of his revolutionary invention. To commemorate the centenary at this year's meeting, the six films selected all deal with aspects of the steel industry.

One of the films, "Continuous Casting at Barrow," will have its first public showing at the Sheffield meeting. Produced by the research and development department of the United Steel Companies, Limited, this colour film shows how 2-in. sq. billets are being produced at high casting speeds in a pilot plant at Barrow. United Steel's second contribution to the programme is "Steel Road," a new documentary which pays its own tribute to Bessemer and depicts steel-making operations at Workington Iron & Steel Company, the last stronghold of the original acid Bessemer process in Britain.

The whole industry from ore mining to finished product is surveyed in the British Iron and Steel Federation's documentary "Steel." By way of contrast, the programme includes two very different examples of the federation's filming activities—a light-hearted cartoon portraying the universality of steel in everyday life, "River of Steel," and a short instructional film on "The Bessemer Converter." Finally, there is a fine colour film on "Forged Steel Rolls," in which Thos. Firth & John Brown, Limited, describes how these products are made, with sequences on their increasingly wide application in modern industry.

POA Conference and Minibition

At the 1956 National Conference and Minibition of the Purchasing Officers' Association to be held at the Spa, Scarborough, from September 27 to 30, following the annual general meeting of the Association, there is to be an address by the president, Mr. H. W. King. The Conference proper will open on the morning of September 28 with a talk on "International Horizons for Purchasing," by Stewart F. Heinritz. A paper is to be given by E. W. Senior, C.M.G., on "British Steel Prospects." This will be followed by a discussion on "The Price Aspect of Purchasing," by W. A. M. Edwards, M.A., B.SC. Sir Stephen Tallents, K.C.M.G., C.B., C.B.E., will talk on "Buying and the Modern Arts of Display." "Problem Materials" will be dealt with by T. B. Henderson; "Oil" by H. C. Hawkins, A.M.I.MECH.E., A.M.I.E.E., and "The Challenge of the Future" by P. T. Appleby. The increasing popularity of the Minibition is proved by the record number this year of more than 130 displays by firms representing all sections of British industry.

TWO ROLL HOUSINGS, each weighing 75 tons and measuring 24-ft. 3½-in. long, 6-ft. deep and 14-ft. wide, which travelled by rail from the Davy and United Engineering Company, Limited, Sheffield to Middlesbrough on August 12, made one of the widest loads ever carried by rail in the north-east. Loads are normally not wider than 9-ft. 3-in. Special wagons carried the housings which could be moved 15-in. to either side to avoid apparatus and installations such as points, levers and signals. Speed was sometimes only 5 m.p.h.

Company News

WARNER & COMPANY, LIMITED, pig-iron manufacturers, of Middlesbrough—A final dividend of 20 per cent. is announced for the year ended June 30, 1956, on the £80,000 ordinary shares. An interim dividend of 5 per cent. was paid on £40,000. The previous year's dividend totalled 40 per cent. on smaller capital. The provisional net profit is £54,353, against £36,413.

W. H. DORMAN & COMPANY, LIMITED, manufacturing engineers and ironfounders, of Stafford—If the capitalization issue of five non-voting "A" ordinary shares for every two ordinary held is passed at the extra-ordinary meeting on August 27, a dividend of 3d. per 2s. share will be paid on the ordinary and "A" ordinary shares. This is equivalent to 10½d. per share on the ordinary as issued at "this date."

ENGLISH ELECTRIC COMPANY, LIMITED—The directors have declared an interim dividend on the £15,221,721 ordinary capital in respect of the year ending December 29, 1956, of 4 per cent., payable on September 15 to stockholders registered on August 13. A similar rate was paid a year ago, but on £11,415,291 before a one-for-three rights issue. This was followed by a final dividend of 8½ per cent. on the present capital.

BILSTON FOUNDRIES, LIMITED—CIC consent has been obtained for the one-for-two scrip issue, and an extraordinary meeting is being held on October 2 to pass the resolutions. Authorized capital is being raised to £450,000 by creating 1,000,000 2s. ordinary shares. Renounceable allotment letters will be posted after the meeting to shareholders registered on September 4. The new shares will rank for dividend for the year ending March, 1957.

TRIPLEX FOUNDRY, LIMITED—Mr. W. H. L. Harrison, the chairman, reveals that the company has during the current year purchased the capital of Sillett & Cooksey, Limited, metal spinners, etc., of West Bromwich. The experience of this company will also be utilized to modernize and operate the Triplex sheet-metal division. No ordinary dividend is recommended for the year ended March 31 (7½ per cent. for 1954-55). A group loss, after tax, of £9,762 was incurred (against the parent company's profit of £6,509). The deterioration in the volume of orders for fuel appliances, Mr. Harrison says, was the main reason for the parent's loss, although increasing costs, impossible to recover in selling prices, played their part.

RUSTON & HORNSBY, LIMITED—Chief feature of the full accounts is the sharp deterioration in the group's liquid position, and the group is now borrowing from its bankers, the chairman, Mr. W. J. Ruston, reveals. This loss of liquidity was due, Mr. Ruston states, to greater internal investment and rising costs. Group capital expenditure during the year amounted to £1,066,000 and outstanding commitments at the year-end were £900,000. There was some fall in output during the year, following on the drop in the order-book and the diminishing defence programme. Another contributory factor was the hiatus created by the withdrawal from production of obsolete designs of engines and their replacement by new designs. The chairman anticipates that their introduction will ultimately lead to increased output.

THE GLASGOW BRANCH of Brightside Heating & Engineering Company, Limited, has now moved into new premises at 6, Lynedoch Crescent, Charing Cross, Glasgow, C.3, 'phone: Douglas 3971.

New Patents

(Copies of complete specifications are obtainable from the Patent Office Sales Branch, 25, Southampton Buildings, Chancery Lane, London, W.C.2, price 3s.)

751,551. Molybdenum Corporation, 500 5th Avenue, New York, 17, USA.

A method for the production of iron and steel where acid conditions prevail. An iron-containing melt is prepared and metal-containing material added to it during furnacing. It is then deoxidized, and a composition containing a rare-earth oxide, a reducing agent, and an alkaline-reacting material are incorporated therein.

751,556. Electric Furnace Products Company, Limited, Canada Life Building, Toronto, Ontario, Canada.

A heat-resistant, boron-free, nickel-base alloy capable of rolling. It contains chromium 14 to 17, iron 8 to 12, molybdenum 4 to 7, titanium 2.25 to 5.0, aluminium 1.75 to 2.50, carbon 0.08 to 0.25 per cent., the remainder being nickel (apart from usual impurities). When melted, the alloy is cast into a sand mould with a hot top, on which should be placed an exothermic hot-topping compound.

751,567. Dominion Magnesium, Limited, 320, Bay Street, Toronto, Canada, Ontario.

Production of magnesium-base alloy, and more particularly the production of such alloys containing one or more metals which have a melting point above the boiling point of magnesium.

Finely-divided magnesium or a finely-divided alloy of it together with a metal which melts below the boiling point of magnesium, are mixed with finely-divided particles of at least one metal which melts above the b.p. of magnesium. The mixture is compacted into dense pellets (magnesium with at least one of beryllium, manganese, zirconium, thorium, nickel, cobalt, and hafnium being their components). The pellets are suspended in a bath of magnesium or an alloy of magnesium (together with zinc, aluminium, cerium, lanthanum and neodymium). The bath is maintained molten until alloying is complete.

751,606. Kogichi Otani, 28, Gazenbo-cho Azabu, Minato-ku, Tokyo, Japan.

A method of casting composite rolls, which is very similar to that claimed by the same patentee in patent 751,226.

751,682 and **751,683.** Ford Motor Company, Limited, 88, Regent Street, London, W.1.

Improvements in, or relating to, shell-moulding process and the moulds produced.

751,682. A mould element comprising a thermally-cured mixture of sand and thermosetting resin. This element is provided in one face with cavities to receive and shape the molten metal and with an opposite face generated in a strike-off operation. Metal passages lead from the first face to the opposite face. The opposite face has an irregular surface providing a comparatively thin section of sand near the edges of the mould and around each of the metal passages through the mould. A stack mould is also claimed.

751,683. Principally claimed is the curing on a freshly formed shell mould, by contacting the mould while supported by the pattern with a mass of pulverulent material (such as sand) which has been heated to a temperature of 350 to 1,300 deg. F.

751,784. Battelle Development Corporation, 505, King Avenue, Columbus, 1, Ohio, USA.

Heat-treating cycles for providing improved mechanical properties in beta-stabilized titanium-base alloys.

Imports and Exports of Iron and Steel in June

The following tables, based on Board of Trade returns, give figures of imports and exports of iron and steel in June. Totals for the first six months of this year and last are also included.

Total Exports of Iron and Steel

Destination.	Month ended June 30.	Six months ended June 30.	
	1956.	1955.	1956.
	Tons.	Tons.	Tons.
Channel Islands	370	3,153	2,661
Cyprus	541	2,337	3,560
Sierra Leone	1,071	4,506	3,478
Gold Coast	2,520	12,387	13,757
Nigeria	6,164	23,575	30,459
Union of South Africa	4,542	38,416	37,928
Rhodesia and Nyasaland	9,282	34,810	44,254
Tanganyika	1,704	7,326	9,818
Kenya	4,418	26,731	26,830
Uganda	429	2,936	3,014
Anglo-Egyptian Sudan	855	9,347	8,081
Mauritius	461	1,226	1,550
Aden	87	4,728	2,908
Bahrain, Qatar, and Trucial States	561	6,365	4,936
Kuwait	1,021	1,721	2,649
India	21,157	61,569	153,607
Pakistan	7,296	23,016	26,004
Singapore	2,316	18,336	15,771
Malaya	3,548	9,637	19,286
Ceylon	1,440	9,296	17,266
British North Borneo	453	1,949	3,464
Hongkong	6,084	24,515	32,062
Australia	13,454	201,371	112,605
New Zealand	13,676	134,223	92,856
Canada	32,756	55,210	148,526
Jamaica	2,175	6,533	12,792
Trinidad	4,705	24,473	20,389
British Guiana	392	3,396	2,568
Other Commonwealth countries	2,839	11,603	13,578
Eire	5,701	28,919	36,281
Finland	3,421	37,056	26,524
Sweden	9,413	66,307	63,116
Norway	7,553	62,642	43,466
Denmark	7,517	41,874	36,289
Western Germany	1,002	4,279	5,996
Netherlands	6,959	50,413	43,750
Belgium	2,292	10,987	20,515
France	649	3,023	4,297
Switzerland	1,099	8,205	7,264
Portugal	988	6,735	4,851
Spain	2,802	40,456	17,569
Italy	1,596	14,113	10,297
Austria	404	1,536	2,543
Yugoslavia	7	9,269	4,539
Greece	296	5,118	2,868
Turkey	927	6,061	2,857
Netherlands Antilles	673	6,544	5,305
Portuguese E. Africa	345	806	1,523
Lebanon	695	5,082	4,657
Egypt	4,067	14,271	26,707
Israel	571	5,278	5,250
Saudi Arabia	570	4,166	7,116
Iraq	2,372	24,211	18,082
Iran	6,158	28,255	40,380
Burma	699	7,168	3,465
Thailand	265	2,835	3,729
Indonesia	1,143	1,808	5,869
Philippine Republic	864	2,844	3,728
USA	3,604	21,226	23,853
Cuba	59	1,943	4,642
Colombia	123	3,472	1,443
Venezuela	6,318	27,856	36,015
Ecuador	82	1,285	1,546
Peru	1,448	4,763	8,983
Chile	135	597	502
Uruguay	839	3,560	2,889
Argentina	3,517	29,478	26,279
Other foreign countries	7,776	17,874	20,637
TOTAL	242,166	1,376,306	1,459,279

Total Imports of Iron and Steel

From	Month ended June 30.	Six months ended June 30.	
	1956.	1955.	1956.
	Tons.	Tons.	Tons.
Rhodesia and Nyasaland	441	1,695	1,503
Australia	50	50	106
Canada	5,013	60,273	28,892
Other Commonwealth countries and Eire	769	5,942	3,321
Soviet Union	27,799	95,442	159,161
Sweden	3,913	14,527	24,049
Norway	6,613	34,832	50,123
Western Germany	14,921	14,468	119,935
Netherlands	8,212	70,187	57,965
Belgium	33,773	60,282	213,854
Luxembourg	5,953	15,472	36,612
France	20,462	88,798	153,840
Italy	530	266	5,981
Austria	3,551	69,069	81,790
Japan	1,960	7,862	9,552
USA	29,956	356,452	313,385
Other foreign countries	5,742	5,383	43,440
TOTAL	169,658	901,000	1,303,509
Iron and steel scrap and waste, fit only for the recovery of metal.	90,035	627,764	500,093

Exports of Iron and Steel, by Product

Product.	Month ended June 30.	Six months ended June 30.	
	1956.	1955.	1956.
	Tons.	Tons.	Tons.
Pig-iron	10,703	28,269	60,773
Ferro-colombium (niobium)	8	44	90
Ferro-tungsten	94	224	565
Other ferro-alloys	493	1,435	2,140
Ingots, blooms, billets, slabs, sheets, and tinplate bars	42	3,055	1,077
Iron bars, rods, angles, shapes, and sections	248	1,948	1,217
Steel bars, rods, angles, sections, and shapes	38,030	217,948	234,720
Iron plates and sheets	18	98	93
Universal plates	318	5,023	2,648
Steel plates, ¼ in. and under ⅛ in.	696	11,545	5,437
Do., ⅛ in. and over	21,297	142,552	121,893
Blacksheets and black plate	18,668	110,323	118,994
Hoop and strip	5,900	53,771	47,024
Tinplate	24,849	151,407	151,915
Decorated tinplate	775	2,091	3,769
Galvanized sheets	15,416	81,893	74,746
Other (incl. tinned sheets, terne-plate, and ternesheets)	1,113	7,986	7,576
Railway and tramway construction material	24,040	135,682	155,368
Wire rods	1,857	15,523	19,007
Wire	6,905	50,464	50,566
Tubes, pipes and fittings	70,027	347,566	395,574
Iron castings	202	4,778	1,075
Steel castings	146	1,040	934
Forgings	321	1,641	2,078
TOTAL	242,166	1,376,306	1,459,279

THE 1957 AMERICAN FOUNDRYMEN'S SOCIETY CONGRESS is to be held in Cincinnati and with it will be an exhibition—a real foundry exhibition, that is castings will be shown and foundry equipment and supplies. The date chosen is from May 6 to 10 inclusive.

HARRISON (BIRMINGHAM), LIMITED, brassfounders, have completed an extension to their premises at Bradford Street, Birmingham. The extensions include a large and attractive canteen, which has been designed to operate on cafeteria lines.

Publications Received

BCIRA Journal of Research and Development, Vol. 6, No. 6. Published by the British Cast Iron Research Association, Alvechurch, Birmingham.

A serious and interesting research on one aspect of the sulphur problem is covered in this issue by the publication of an article "Sub-surface Blowholes in Grey Irons and their Association with Manganese-sulphide Segregation," by W. G. Tonks. He has summarized the work in the following statement:—"The occurrence of small sub-surface blowholes in association with manganese-sulphide segregations has been previously reported*. The present work provides more evidence of this type of defect and reports and illustrates a number of examples collected from seven different foundries. With one exception, all the castings concerned were poured in green sand. The experimental work which follows was carried out to examine the influence of variations in manganese and sulphur content and to study the effect of pouring temperature on the incidence of sub-surface blowholes. The defects were successfully reproduced experimentally, and manganese-sulphide segregation and slag-like inclusions were again found to be associated with the defective areas in the test castings. Low pouring temperatures appear to be the chief contributing factor to these defects. At a given pouring temperature the product manganese content multiplied by the sulphur content of the metal has a critical value which when exceeded favours the occurrence of sub-surface blowholes. From the practical point of view it would appear to be easier for the foundryman to control the pouring temperature, and possibly the manganese content, rather than the sulphur content. The advantage of a high cupola melting temperature may however be lost by tapping into cold ladles and also by slow metal distribution. Close attention should be paid to ladle cleanliness, since contaminated ladles may be a contributing factor to the formation of sub-surface blowholes."

A second research deals with "Pinholing in Cast Iron and its Relationship to the Hydrogen Pick-up from the Sand Mould." This research has been carried out by Mr. J. V. Dawson and Mr. L. W. L. Smith, B.Sc., and includes the following summary:—"Pinholes are generally groups of small blowholes lying just below the cast surface, and on examination are seen to be surrounded by a thin film of graphite. Graphite films are formed under inert conditions. It is suggested that pinholes arise from the evolution of hydrogen picked up by the reaction of molten metal with the moisture of the mould. Pinholing in grey irons is shown to be aggravated by the simultaneous presence of small amounts of aluminium and titanium. Coal-dust and pitch reduce the tendency for pinholing to occur. Hydrogen pick-up increases with aluminium, magnesium and manganese. Hydrogen pick-up slightly increases with coal-dust. Some limited correlation between hydrogen pick-up and pinholing is shown. The overflow-mould method used to measure hydrogen pick-up may not distinguish between factors influencing the total pick-up of hydrogen and factors influencing the rate of pick-up. This may be the reason for the limited correlation between hydrogen pick-up and pinholing. From the practical point of view, the results obtained in this paper suggest that the foundryman can reduce his pinholing problems by using adequate coal-dust or pitch in the sand, and in grey and nodular cast irons by avoiding combined traces of aluminium and titanium."

* BCIRA Journal, 1954 (February), 5, 180.

The third Report included covers the subject of "The Influence of Hydrogen in the Titanium-CO_2 Process" by Mr. J. V. Dawson, B.B. Bach, B.Sc., and L. W. L. Smith, B.Sc. This process was invented by the Association (Norbury and Morgan) in 1933. Since then, the tools for research have been revolutionized and using them, new knowledge has been gained. The following short summary gives the present situation:—"Titanium additions are shown to refine the graphite structure in grey cast iron and the bubbling of a dry, inert gas enhances this refinement. Bubbling hydrogen has an opposite, coarsening effect on the graphite. Gas analyses are given and these show that bubbling an inert gas such as dried CO_2 or argon tends to lower the hydrogen content, particularly if it is high. Bubbling hydrogen raises the hydrogen content. The alternate refinement and coarsening of the graphite by CO_2 and hydrogen bubbling is shown to be solely due to changes in hydrogen content. The part played by sulphur in controlling graphite formation is discussed."

Productivity in Electroplating, by G. A. Edwards and E. A. Ollard. Published as Report No. 56 by the British Non-Ferrous Metals Research Association, Euston Street, London, N.W.1.

Over the past two or three years, the British Non-Ferrous Metals Research Association has been operating a special advisory service to electroplaters designed to assist in increasing productivity and technical efficiency in the industry. The Association's investigators have visited the plating shops of a number of firms by arrangement with the management to make a detailed survey of the practice. Each survey has lasted from a few days to two or three weeks according to the size of the plant and, based on this survey, a confidential report was made available to the management of each firm indicating how productivity and efficiency could be increased. Certain general conclusions and recommendations have come out of this work and these have been embodied in this Report. This is not a technical Report dealing with the actual plating processes employed, but is to some extent the converse of the now familiar productivity team reports issued by the Anglo-American Council on Productivity. It picks out the points where practice is at fault, where production is hindered, or where layout is bad, and indicates how improvements can be made.

All concerned with the operation of plating shops, whether managers, accountants, or shop supervisors, will find much of interest and value in a report drawn up by investigators familiar with, but sufficiently detached from, the industry to take a truly objective view of every-day practices which those engaged in the industry take for granted. The Report is available free of charge on application to the Association.

Physiotherapy in Industry. Issued by the Chartered Society of Physiotherapy, Tavistock House (South), Tavistock Square, London, W.C.1.

Taking the form of a four-page pamphlet, this publication is of interest to large industrial concerns where the rate of absenteeism through sickness and injury is sufficiently high as to justify the installation of a physiotherapy department. The advantages of such an installation, when and where applicable, are well set out and worth pondering over. The question of hospital treatment or treatment at the works is still, to the reviewer's mind, debatable.

Personal

RICHARDSONS, WESTGARTH AND COMPANY, LIMITED, engineers, Hartlepool, have received an order worth £500,000 for two gas-turbine electricity-generating sets for the Pakistan Industrial Corporation.

Mr. B. H. DYSON, general works manager of Hoover, Limited, has been made a director of Hoover (Electric Motors), Limited. He is a director of Hoover (Washing Machines), Limited.

Mr. R. WOOD has been appointed chairman of Moler Products, Limited. He succeeds Mr. E. W. D. TENNANT, who has relinquished the position as chairman but continues as director.

Tecalemit, Limited, Plymouth, announce that Mr. J. DEE SHAPLAND, B.Sc., has been appointed chief chemical engineer and technical director of Foamite, Limited—a subsidiary firm.

Mr. G. A. WHIPPLE, chairman and managing director of Hilger & Watts, Limited, London, S.E.5, has been elected president of the Scientific Instrument Manufacturers Association.

Col. Sir HAROLD SMITH has been reappointed chairman of the Gas Council when his present term of office expires on December 31. Sir HENRY JONES has been reappointed as deputy chairman of the Council from February 1 next year.

Metropolitan-Vickers Electrical Company, Limited, announces that Mr. E. TANKARD has been appointed comptroller, Mr. A. COOPER accountant, *and* Mr. A. G. EVANS assistant accountant. Mr. Tankard succeeds Mr. E. Salmon, who has retired from the company.

Mr. COLIN KIRK, vice-president of the British Chamber of Trade in Paris, has been named Chevalier de la Légion d'Honneur for services to Franco-British trade. Mr. Kirk was formerly for 20 years representative in France of Thos. W. Ward, Limited, Sheffield.

THE INCORPORATED PLANT ENGINEERS are organizing a Southern Regional Conference to be held at the Grand Hotel, Bournemouth, from October 12 to 14. The theme of the Conference will be "Future Developments in Plant Engineering." Details are available from Mr. W. R. Selwood, Chandler's Ford, Southampton.

Fellowships for post-graduate research have been awarded by the British Oxygen Company, Limited, to Mr. C. M. GEORGE, of Bristol University, for research in the Department of Chemistry, Bristol, and Mr. N. G. PARSONAGE, of New College, Oxford, for research in the Inorganic Chemistry Laboratory, Oxford University.

Mr. J. E. BELLISS, managing director of Belliss and Morcom, Limited, has been elected president of the Birmingham Chamber of Commerce for 1956-57. Mr. Belliss joined the company in 1924 and was elected to the board in 1938. He is also a director and chairman of British Arca Regulators, Limited, a subsidiary of Belliss and Morcom, Limited.

Mr. C. N. KINGTON has resigned his post as group manager of the British Iron & Steel Research Association's Sheffield laboratories, director of research of the Cutlery Research Council, and research superintendent of the File Research Council in order to become chief mechanical and electrical engineer of Husband & Company, consulting engineers and architects, who have offices in Sheffield, London and Ceylon. He will take up the appointment on September 3.

Sir PERCY MILLS, chairman of W. & T. Avery, Limited, whose Soho Foundry which recently ceased production has a close association with Boulton, Watt and Murdoch, is to unveil the statues of the three industrial pioneers outside the College of Commerce, Birmingham, on September 14. The cost of the statues has been estimated at £14,550 of which £8,000 was a gift from the late Mr. R. Wheatley. The balance has been met by the Birmingham Corporation. The sculptor of the statues was Mr. W. Bloye.

After visiting South Africa and Australia, Mr. M. J. REANEY, director and general manager of Colt Ventilation, Limited, is proceeding to California to launch a new subsidiary company, the Colt Ventilation of America Inc., of 4652, Hollywood Boulevard, Los Angeles 27. Mr. Reaney will remain in Los Angeles until December and will be joined shortly after his arrival by one of Colt's most experienced and successful senior technical consultants, Mr. H. M. McLean from Edinburgh, who is to take up permanent residence as the Colt representative there.

Obituary

Mr. JOHN GRANT MACDONALD, who was a special director and a manager of William Beardmore & Company, Limited, steel manufacturers and founders, has died at the age of 70. He was awarded the OBE while manager of the company's armoured-plating department during the last war, and retired in 1954 after nearly 50 years' service.

Mr. EDMUND JOSEPH LOWE, who died recently at the age of 66, had been associated with Thos. Firth & John Brown, Limited, Sheffield, for more than 45 years. He was appointed assistant works manager in 1935, a local director in 1941, and works manager in 1944. Later he was made a full director. During the recent war Mr. Lowe was closely associated with committees of the Iron and Steel Control and the Ministry of Aircraft Production dealing with special and alloy steels. He was made an OBE in 1944.

Sir WILLIAM PATERSON, who founded the Paterson Engineering Company, Limited, water purification engineers, etc., of London, W.C.2, in 1902 and remained its chairman until January of last year, died on August 9 at the age of 82. In 1938, Sir William was asked by the Minister of Defence, Sir John Anderson (now Lord Waverley), to assist in the production of a cheap household shelter that would withstand blast and flying débris. As a result Sir William was responsible for the production of the original design and model of the Anderson shelter. He was knighted in 1944.

Mr. J. W. RODGER, managing director of Bruce Peebles & Company, Limited, engineers, Edinburgh, died on August 16 in a local nursing home at the age of 69. A native of Northern Ireland, he received his technical education in England and served his apprenticeship in the West of Scotland. For several years he was chief transformer designer with Ferranti, Limited, Hollinwood, and was also with the Hackbridge Electrical Construction Company, Limited. Mr. Rodger became an associate of the Institution of Electrical Engineers in 1916 and a member in 1938. He joined the Edinburgh firm in 1924 to inaugurate the development and manufacture of transformers, a new industry for Scotland at that time. In 1941, he was elected to the board of the company, and in 1943 was appointed general manager. Two years later he became managing director.

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News in Brief

DISTINGTON ENGINEERING COMPANY, LIMITED, has plans for the proposed erection of extensions to the foundry at Chapel Bank Works, Workington, Cumberland.

OF THE TOTAL ironfounding labour force at Falkirk, only between four and five per cent. are now working on short time. Four months ago, nearly half the workers were on short time, due to the Australian and British financial restrictions.

AFTER completion of relining, the Queen Anne blast furnace at the works of Appleby-Frodingham Steel Company, Scunthorpe, a branch of the United Steel Companies, Limited, will have a hearth diameter of 31 ft., which it is stated is larger than that of any other known blast furnace. The reline began on July 21 and the furnace is expected to be back in operation about September 1.

THE Sir Alexander Roger Travelling Scholarship, instituted by British Insulated Callender's Cables, Limited, as a tribute to its first honorary president, has been awarded this year to Mr. J. R. Pugh, assistant to the chief traction engineer, British Insulated Callender's Construction Company, Limited. He will use the scholarship to visit Germany, Austria, Sweden and France to study the design, erection, and performance of high-voltage a.c. traction equipment.

A SPECIAL TRAIN over the weekend of August 11 transported 300 tons of special equipment made at the Davy and United Engineering Company, Limited, Sheffield to Middlesbrough for shipment to Spain. It comprised the heavier parts for a 42-in. blooming and slabbing mill which will be part of the new national steelworks being erected near Aviles. The complete order was worth over £1,000,000 and the firm had already sent 900 tons and a further 2,000 tons is to follow.

PAYMENTS for long service are to be made to some of the 300 employees who received a week's notice on August 17 from the Wolverhampton Die Casting Company, Limited. In a joint statement, Mr. K. Whitehead, joint managing director and Mr. G. F. Wootton, district secretary of the Transport and General Workers' Union, said the firm would pay an extra week's wages to those with three years' service, and an extra two weeks to those with ten years' service or more.

THE four-day working week, introduced towards the end of July at the works of Sheepbridge Stokes, Limited, Chesterfield, is to continue and employees in the foundry engaged in making cylinder liners for the motor industry have been notified accordingly. The Lockheed Hydraulic Brake Company, Limited, Leamington, announced last week that about 400 of their 5,500 workers are to be declared redundant because the general recession in the car trade has caused a fall in demand for the company's products. Most of the dismissals will take effect on August 31.

Mr. B. O. SMITH of the British Iron and Steel Research Corporation; Dr. A. PARKER of the Department of Scientific and Industrial Research, and Mr. W. J. DICKIE of the Federation of British Industries, London, will be among the speakers at the residential executive course on fuel and power economy which the University of Birmingham Institute for Engineering Production is organizing from October 8 to 19 in association with the Fuel Technology Advisory Committee of the West Midlands Advisory Council for Further Education. The course has been arranged primarily for executives in charge of production, process development and plant engineering.

EXAMINATION of the work-study theory and its practical application as the direct approach to increasing industrial productive efficiency by the more effective employment of existing equipment, materials and personnel—is the primary purpose of the residential executive course which is being organized in Birmingham from September 10 to 21 by the Institute for Engineering Production of the University of Birmingham. The course aims also to provide an opportunity for discussion between production managers and other executives on the practical problems arising in the organization and promotion of work-study programmes directed towards increasing productivity and reducing costs.

A BOOKLET about the firm with a foreword by Mr. H. Humphries, managing director of Hadfields, Limited, steelmakers, Sheffield, has been prepared for presentation to the 5,500 employees on their return from holiday on August 20. The information covers works' routine, working agreements, avoidance of accidents and welfare and other facilities available. Mr. Humphries writes: "The company's objective to be of service to industry will continue. All employees must share that responsibility. They are expected to discharge their duties faithfully to ensure that customers on whom they depend for their livelihood receive on schedule time products manufactured from finest quality materials made by craftsmen of the highest repute." The 1,000 staff of the firm is to have a separate booklet which is in preparation.

TWO BIG ORDERS worth more than half a million pounds have just been received by Euclid (Great Britain), Limited, manufacturers of heavy earth-moving equipment, Newhouse, Lanarkshire. Both orders will be paid for in dollars. The larger order comes from Canada—the biggest single overseas market for Euclid's British-made products. The contract was arranged by the firm's agent in the Dominion and is to the value of £450,000. The other order, worth about £100,000, has been placed by an American contractor. The equipment is to be used on development schemes in Pakistan. During the summer, two new bays have come into operation at their works, providing an additional 100,000 sq. ft. of manufacturing space and increasing the area covered by the firm's plant to 261,000 sq. ft.

THE Midland Regional Board for Industry which is to sponsor research into factory building and operating problems, has now announced that the project will start at the beginning of September and will take two years. It will be carried out under the auspices of the Building Research Station of the Department of Scientific and Industrial Research. The research funds will be in the care of three trustees who are Major C. R. Dibben, chairman of the Midland Regional Board for Industry; Sir Herbert Manzoni, Birmingham city engineer and surveyor; and Mr. R. T. Jones, district manager of Lloyds Bank, Limited. An advisory committee has been set up to guide and assist the Building Research Station in carrying out the project. The research will be directed broadly as under:—(1) Analysis of space utilization in a selected sample of factories in terms of process space, storage, offices and amenities; (2) Investigation of the advantages and disadvantages of single-storey factories operating the same general processes; (3) Investigation of building costs in relation to other production costs, and (4) A study of the influence on design and cost of density of plant, raw materials handling, vibration, constructional loading, electricity, gas and water supplies, supervision, canteens, lighting, ventilation, etc.

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Raw Material Markets

Iron and Steel

The trend of business at the foundries seems to be much the same as that prevailing before the stoppage for the holiday break. Most foundries suspended deliveries of raw materials during the holidays, but supplies on hand at the resumption were sufficient. All grades of pig-iron are coming forward satisfactorily, most of the producing furnaces having supplies in stock on which they can draw. In fact, with the reduced home demand, additional tonnages are being offered for export; this applies to all foundry qualities and hematite.

The resumption of operations at plants affected by the dispute in the motor-car trade is unlikely to make any material change in the call for castings in the near future, and the engineering foundries catering for these concerns are still far from busy, many of them, in fact, still working short time. This is reflected in their demands for low-phosphorus iron and hematite, although some of the surplus iron is being absorbed by other engineering foundries enjoying brisker conditions. The steelworks are large users of hematite, producers of which are able to dispose of their outputs promptly, but the supply of low-phosphorus iron is easier.

Business is quiet at many of the light and jobbing foundries and so are their demands for high-phosphorus pig-iron. Production of this grade appears to be adequate to meet all demands, so that the furnaces which changed over from this grade to the supply of basic steelmaking pig-iron are likely to continue on the latter grade in view of the heavy claims of the steelworks.

Most of the re-rollers have completed their annual holidays and are able to resume work with good order-books and a continued regular demand for all their products, including small bars, light sections, strip, etc. Although some mills were unable to accept deliveries of steel semis during the closure, many made arrangements to take in the tonnages which the works were able to despatch. Their consumption calls for regular deliveries. There is a scarcity of the smaller sized billets in 2-in. square and also in special steels, and some re-rollers would prefer larger supplies of untested steel to fulfil the orders which call for this grade. Good supplies have previously been received from abroad, but few, if any, home steelworks will supply.

Non-ferrous Metals

With the exception of lead, non-ferrous metal markets are flat and featureless on both sides of the Atlantic. The Suez crisis is still acting as a shock absorber and quotations are only gradually softening. Copper, it would appear, is trying to go lower, but tension in the Middle East and the continued disturbances on the Copperbelt are steadying influences. In Rhodesia labour strikes have been under way at Chibuluma and at Nchanga, the sixth and seventh mines in succession to be so affected. The Chibuluma workers, however, returned on Tuesday after a six-day stoppage. Demand in London is only fair and is quiet in America, where the Custom smelter price has come back ¼ cent to 39.50 cents a pound. All signs point to the improved production and supply position making itself felt in a further lowering of the price.

Tin is quietly steady, but the collapse of the threatened industry-wide strike in Malaya caused the quotation to shed a few points. Both lead and zinc have been fluctuating in sympathy with the price of copper, as there have been no new developments affecting consumption and supply in either metal. Demand for lead is much better than that for zinc, and in the United States there is some talk of the price rising ¼ cent to 16½ cents a pound should buying pick up on any scale from the automobile industry. It is reported from Greenland that a new deposit containing some hundreds of pounds of almost pure lead has been located near Lake Lummon.

With regard to zinc it will be at least another week before the US steel industry is operating at anything near capacity and until demand eventuates from that source and from the automobile industry the stocks of zinc on hand are more than adequate to deal with day-to-day requirements. Indeed, the Government stockpiling authorities will no doubt be offered more metal than they can reasonably absorb. For the moment, however, the price remains unchanged 13.50 cents a pound for "Prime Western" grade, East St. Louis.

Official metal prices were as follow:—

COPPER, Standard—*Cash:* August 16, £297 to £298; August 17, £296 to £296 10s.; August 20, £293 10s. to £294; August 21, £290 10s. to £291; August 22, £294 10s. to £295.

Three Months: August 16, £297 to £298; August 17, £296 to £296 10s.; August 20, £294 to £294 10s.; August 21, £290 10s. to £291; August 22, £295 to £295 10s.

TIN, Standard—*Cash:* August 16, £796 to £770; August 17, £766 to £767; August 20, £764 to £765; August 21, £762 to £763; August 22, £764 10s. to £765 10s.

Three Months: August 16, £767 to £768; August 17, £764 to £765; August 20, £761 to £762; August 21, £760 to £761; August 22, £763 to £764.

LEAD—*Second half August:* August 16, £115 10s. to £115 15s.; August 17, £115 to £115 5s.; August 20, £114 10s. to £114 15s.; August 21, £114 10s. to £114 15s.; August 22, £114 10s. to £114 15s.

Second half November: August 16, £113 15s. to £114; August 17, £113 to £113 5s.; August 20, £112 15s. to £113; August 21, £113 to £113 10s.; August 22, £113 5s. to £113 10s.

ZINC—*Second half August:* August 16, £95 to £95 5s.; August 17, £94 10s. to £94 15s.; August 20, £94 10s. to £94 15s.; August 21, £94 to £94 10s.; August 22, £94 5s. to £94 10s.

Second half November: August 16, £93 to £93 5s.; August 17, £92 15s. to £93; August 20, £92 15s. to £93 5s.; August 21, £92 10s. to £92 15s.; August 22, £92 15s. to £93.

Social Skills of Management

The Social Skills of Management course is now in its fifth year. A number of alterations in the syllabus as well as refinements in teaching techniques have been incorporated in the plan for the coming session. A course in applied leadership, concentrating on the man-management function of executives, will commence at the Polytechnic, 309, Regent Street, London, W.1, on November 5. A considerable amount of training in interviewing, technical and general report writing, and chairmanship is included at every stage, most of the work being done by means of conference-leading and discussion methods. Details of the course, "Social Skills of Management," can be obtained from the Registrar, Department of Management Studies, St. Katharine's House, 194, Albany Street, London, N.W.1. The department is also offering a 15-week course on financial background for policy-making, which starts on October 3.

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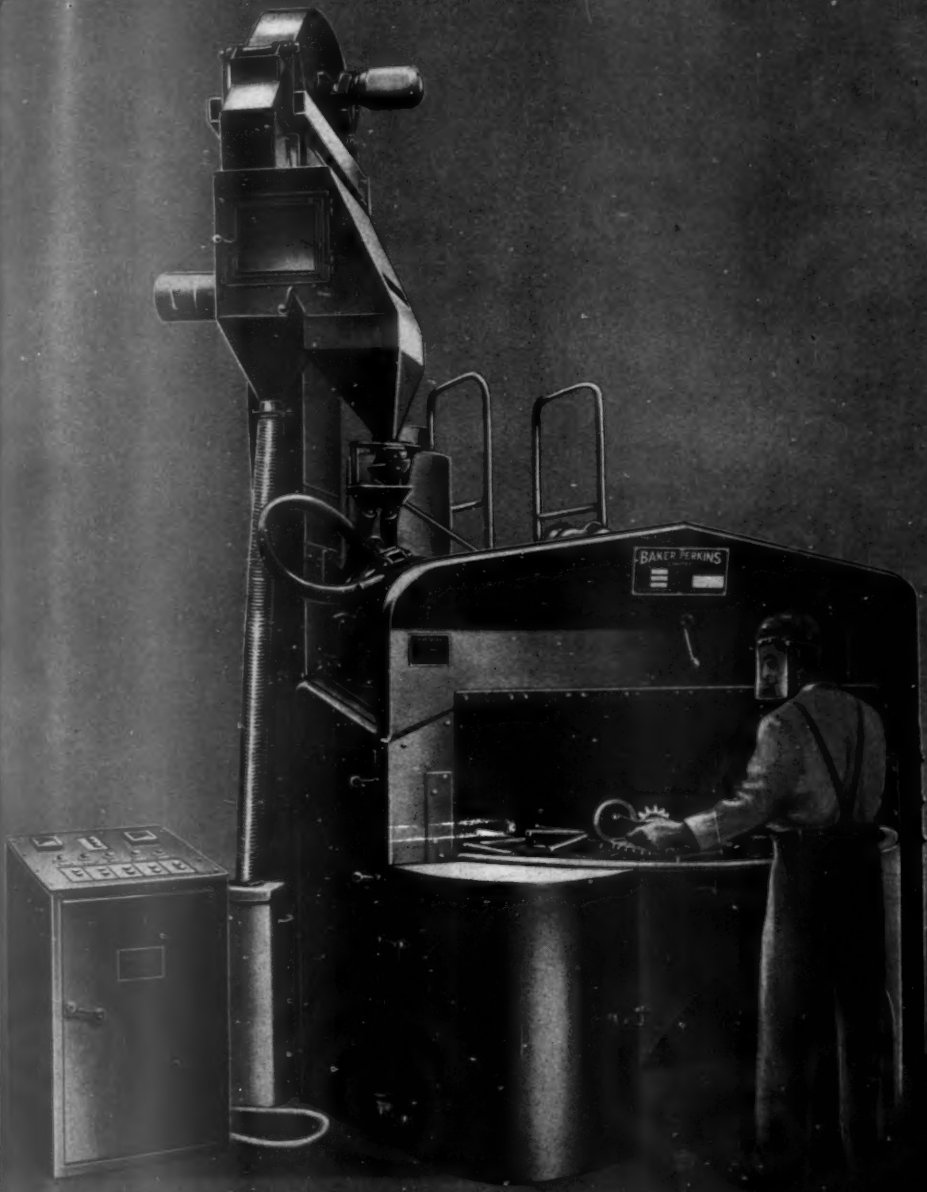

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Current Prices of Iron, Steel, and Non-ferrous Metals

(Delivered unless otherwise stated)

August 22, 1956

PIG-IRON

Foundry Iron.—No. 3 IRON, CLASS 2:—Middlesbrough, £17 11s. 0d.; Birmingham, £17 3s. 3d.

Low-phosphorus Iron.—Over 0.10 to 0.75 per cent. P, £20 8s. 0d., delivered Birmingham. Staffordshire blast-furnace low-phosphorus foundry iron (0.10 to 0.50 per cent. P, up to 3 per cent. Si), d/d within 60 miles of Stafford, £20 12s. 3d.

Scotch Iron.—No. 3 foundry, £21 14s. 6d., d/d Grangemouth.

Cylinder and Refined Irons.—North Zone, £23 16s. 6d.; South Zone, £23 19s. 0d.

Refined Malleable.—P, 0.10 per cent. max.—North Zone, £25 4s. 0d.; South Zone, £25 6s. 6d.

Hematite.—Si up to 2 per cent., S. & P. over 0.03 to 0.05 per cent. :—N.-E. of England (local iron), £21 7s. 6d.; Scotland (Scotch iron), Zone S. 1, £21 14s. 0d.; Sheffield, £22 14s. 6d.; Birmingham, £23 2s. 0d.; Wales (Welsh iron), £21 7s. 6d.

Basic Pig-iron.—£18 3s. 0d. all districts.

FERRO-ALLOYS

(Per ton unless otherwise stated, delivered)

Ferro-silicon (6-ton lots and over).—45 per cent. Si, £48 0s. 0d. to £50 5s. 0d., scale 16s. 0d. to 17s. 6d. per unit; 75 per cent. Si, £70 0s. 0d. to £73 2s. 6d., scale 16s. 0d. to 17s. 6d. per unit.

Ferro-vanadium.—50/60 per cent., 27s. 6d. per lb. of V.

Ferro-molybdenum.—65/75 per cent., carbon-free, 11s. 6d. per lb. of Mo.

Ferro-titanium.—20/25 per cent., carbon-free, £250 0s. 0d.; 38/40 per cent., £299 0s. 0d.

Ferro-tungsten.—80/85 per cent., 17s. 2d. per lb. of W.

Tungsten Metal Powder.—98/99 per cent., 20s. 2d. per lb. of W.

Ferro-chrome (6-10 ton lots).—4/6 per cent.C, £93 10s.0d. to £95 0s. 0d., basis 60 per cent. Cr, scale 29s. 9d. to 32s. 0d. per unit; over 6 per cent. C, £92 10s. 0d. to £93 0s. 0d., basis 60 per cent. Cr, scale 29s. 9d. to 32s. 0d. per unit; 2 per cent. C,* 2s. 1d. per lb. Cr; 1 per cent. C,* 2s. 1½d. per lb. Cr; 0.15 per cent. C,* 2s. 2½d. per lb. Cr; 0.10 per cent. C,* 2s. 2¾d. per lb. Cr; 0.06 per cent. C,* 2s. 3d. per lb. Cr.

Metallic Chromium.—98/99 per cent., 7s. 0d. to 7s. 6d. per lb.

Metallic Manganese.—93/95 per cent., carbon-free, £249 0s. 0d.; 96/98 per cent., £259 0s. 0d. to £265 0s. 0d.

Ferro-columbium.—65/75 per cent., Nb + Ta, 22s. 6d. to 23s. 6d. per lb., Nb + Ta.

Ferro-manganese (home).—78 per cent., £66 0s. 0d.

SEMI-FINISHED STEEL

Re-rolling Billets, Blooms, and Slabs.—BASIC: Soft, u.t., £28 19s. 0d.; tested, 0.08 to 0.25 per cent. C, £29 19s. 0d.; hard (0.41 to 0.60 per cent. C), £31 0s. 6d.; silico-manganese, £39 10s. 0d.; free-cutting, £33 3s. 0d. SIEMENS MARTIN ACID: Up to 0.25 per cent. C, £36 14s. 6d., silico-manganese, £39 17s. 6d.

Billets, Blooms, and Slabs for Forging and Stamping.—Basic, soft, up to 0.25 per cent. C, £34 13s. 6d.; basic, hard, over 0.41 up to 0.60 per cent., C, £35 16s. 0d.; acid, up to 0.25 per cent. C, £38 17s. 6d.

FINISHED STEEL

Heavy Plates and Sections.—Ship plates (N.-E. Coast), £35 7s. 0d.; boiler plates (N.-E. Coast), £37 17s. 0d.; floor plates (N.-E. Coast), £36 16s. 0d.; sectional material, N.-E. Coast, £33 16s. 6d.

Small Bars, Sheets, etc.—Rounds and squares, under 3 in., untested (4-ton lots), £36 3s. 0d.; flats, 5 in. wide and under (4-ton lots), £36 3s. 0d.; hoop and strip, £36 12s. 6d.; uncoated strip mill coils, hot rolled, under 3mm. to 12g., £38 16s. 0d.; black sheets (hand mill), 17/20 g., £50 4s. 6d.; galvanized corrugated sheets, 24 g., £62 7s. 0d.

Alloy Steel Bars.—1 in. dia. and up: Nickel, £61 13s. 9d.; nickel-chrome, £85 10s. 6d.; nickel-chrome-molybdenum, £96 16s. 6d.

NON-FERROUS METALS

Copper.—Cash, £294 10s. 0d. to £295 0s. 0d.; three months, £295 0s. 0d. to £295 10s. 0d.; settlement, £295 0s. 0d.

Copper Tubes, etc.—Solid-drawn tubes, 2s. 11¾d. per lb.; rods, 329s. 3d. per cwt. basis: 20 s.w.g., 362s. 6d. per cwt.

Tin.—Cash, £764 10s. 0d. to £765 10s. 0d.; three months, £763 0s. 0d. to £764 0s. 0d.; settlement, £765 10s. 0d.

Lead (Refined Pig).—Second half August, £114 10s. 0d. to £114 15s. 0d.; second half November, £113 5s. 0d. to £113 10s. 0d.

Zinc.—Second half August, £94 5s. 0d. to £94 10s. 0d.; second half November, £92 15s. 0d. to £93 0s. 0d.

Zinc Sheets, etc.—Sheets, 15 g. and thicker, all English destinations, £126 0s. 0d.; rolled zinc (boiler plates), all English destinations, £123 15s. 0d.; zinc oxide (Red Seal), d/d buyers' premises, £110.

Brass Tubes, etc.—Solid-drawn tubes, 2s. 4¾d. per lb.; rods, drawn, 3s. 2½d.; sheets to 10 w.g., 315s. 0d. per cwt.; wire, 3s. 0d.; rolled metal, 300s. 0d. per cwt.

Brass (Brazing).—BS1400, B3 (65/35), £102; B6 (85/15), —; BS249, —.

Brass (High Tensile).—BS1400, HTB1 (30 tons), —; HTB2 (38 tons), —; HTB3 (48 tons). —.

Gunmetal.—BS1400, LG2 (85/5/5/5), £267; LG3 (86/7/5/2), £274; G1 (88/10/2/½), —; (88/10/2/1), —.

Phosphor Bronze.—BS1400, PB1 (AID released), £336 per ton.

Phosphor Bronze Strip, etc.—Strip, 433s. 6d. per cwt.; sheets to 10 w.g., 458s. 0d. per cwt.; wire, 4s. 5½d. per lb.; rods, 3s. 9½d.; tubes, 3s. 7¾d.; chill cast bars: solids 3s. 9½d., cored 3s. 10½d. (CHARLES CLIFFORD, LIMITED).

Nickel Silver, etc.—Rolled metal, 3 in. to 9 in. wide × 0.056, 4s. 1¼d. per lb.; round wire, 10g. in coils (10 per cent.), 4s. 6d.; special quality turning rod, 10 per cent., ½ in. dia., in straight lengths, 4s. 5d. All prices are net.

Other Metals.—Magnesium, ingots, 2s. 4d. per lb. Antimony, English, 99 per cent., £210 0s. 0d. Quicksilver, ex-warehouse, £83 15s. 0d. Nickel, £519 0s. 0d. Aluminium ingots, £198 10s. 0d.; aluminium bronze (BS1400), AB1, —; AB2, £315. Solder, brazing, BS1945, type 8 (50/50), 3s. 1d. per lb., type 9 (54/46), 3s. 4½d. per lb.

* Average 68–70 per cent.